505-10-33

MISSION OPERATIONS AND DATA SYSTEMS DIRECTORATE

EOS AM-1
Detailed Mission Requirements

November 1996

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

EOS AM-1 1010— Approval Authority

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PREPARED BY: E. Chang EOS AM Project Operations Manager	DATE	PREPARED BY: A.C. Kelly EOS Mission Operations Manager	DATE
APPROVED BY: C. Scolese EOS AM Project Manager		REVIEWED BY: G. Smith EOS Data Systems Manager	
		APPROVED BY: D. Harris Earth Science Data and Information System Associate Director	
NETWORK/RANGE		NETWORK/RANGE	
CONCURRED BY: D. Stuchlik Project Manager, EOS AM-1 Backup Ground Stations GSFC/WFF Code 822	DATE	CONCURRED BY: E.B. Luers Telecommunications and Mission Operations Manager, Jet Propulsion Laboratory	DATE
APPROVED BY: A.L. Torres Director, GSFC/WFF Code 800		APPROVED BY: P. T. Westmoreland Director, Telecommunications and Mission Operations Directorate Jet Propulsion Laboratory	

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ACE	attitude control electronics
ACRIM	Active Cavity Radiometer Irradiance Monitor
ADC	Affiliated Data Center
AGS	Alaska Ground Station
AIRS	Atmospheric Infrared Sounder
AMSU	Advanced Microwave Sounding Unit
AOS	Advanced Orbiting System
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
BDU	bus data unit
bps	bits per second
BPSK	binary phase shift key
C&DH	Command and Data Handling
C&DHS	Command and Data Handling Subsystem
C&T	command and telemetry
CADU	channel access data unit
CCSDS	Consultative Committee for Space Data Systems
CERES	Clouds and Earth's Radiant Energy System
CIESIN	Consortium for International Earth Sciences Information Network
CLCW	command link control word
CLTU	command link transmission unit
CMD	command
Co-I	co-investigator
COMS	Communication Subsystem
COP	command operations procedure
CPHTS	Capillary Pumped Heat Transport System
CP-PDU	Central Processing-Protocol Data Unit
CSA	Canadian Space Agency
CSMS	Communications and System Management Segment
CSS	Coarse Sun Sensor
CTIU	Command and Telemetry Interface Unit
CTL	Compatibility Test Laboratory
CTV	Compatibility Test Van
CVCDU	coded virtual channel data unit
DAAC	Distributed Active Archive Center
DADS	Data Archive and Distribution System
DAR	Data Acquisition Request
DAS	Direct Access Service
dB	decibel
DB	Direct Broadcast
dBM	dB milliwatt
dBI	dB isotropic
dBW	dB - watt
DDL	Direct Downlink
deg	degree

DMR	Detailed Mission Requirements
DP	Direct Playback
DPM	Deputy Project Manager
DSN	Deep Space Network
EBnet	EOSDIS Backbone Network
ECT	EOC Compatibility Tests
EDC	EROS Data Center
EGS	EOSDIS Ground System
EIRP	equivalent isotropically radiated power
EDOS	EOS Data and Operations System
ELV	expendable launch vehicle
EMC	electromagnetic charge
ENG	engineering
EOC	EOS Operations Center
EOL	end of life
EOS	Earth Observing System
EOS-AERO	EOS Aerosol
EOS-ALT	EOS Altimeter
EOS AM	EOS Morning Launch (AM)
EOS-CHEM	EOS Chemistry
EOS PM	EOS Afternoon Launch (PM)
EOSDIS	Earth Observing System Data and Information System
EOSP	Earth Observing Scanner Polarimeter
EPS	Electrical Power Subsystem
EROS	Earth Resources Observation System
ESA	European Space Agency
ESDIS	Earth Science Data and Information System
ESN	EOSDIS Science Network
ETS	EOSDIS Test System
FDD	Flight Dynamics Division
FDIR	fault detection, isolation, and recovery
FLG	flag
FOD	Flight Operations Director
FOS	Flight Operations Segment
FOT	Flight Operations Team
FOV	field of view
GCRP	Global Change Research Program
GCMR	Ground Control Message Request
GDS	Ground Data System
GFE	government furnished equipment
GHz	gigahertz
GN	Ground Network
GNCS	Guidance, Navigation and Control Subsystem
GPS	Global Positioning System
GSFC	Goddard Space Flight Center
GSI	ground system integration
GSIF	Ground Station Interface Facility
GSIM	Ground System Integration Manager
GSIWG	Ground System Integration Working Group

H/K	housekeeping
HDR	header
H&S	health and safety
Hz	Hertz
I&T	integration and test
ICC	Instrument Control Center
ICD	Interface Control Document
ID	identifier
IDB	instrument data base
IF	intermediate frequency
IET	Instrument Engineering Team
IGCRP	International Global Change Research Program
I I	interdisciplinary investigator
IIRV	Improved Interrange Vectors
IMS	Information Management System
IOC	in-orbit checkout
IP	International Partner
IPGS	International Partner Ground System
IPOC	International Partner Operations Center
IRU	inertial reference unit
ISM	Instrument Systems Manager
IST	Instrument Support Terminal
IV&V	Independent Verification and Validation
IWG	Investigator Working Group
JPL	Jet Propulsion Laboratory
kbps	kilobits per second
Kbps	kilobytes per second
kg	kilogram
kHz	kilohertz
km	kilometer
KSA	Ku-band single access
kW	kilowatt
LaRC	Langley Research Center
lb	pound
lb-m	pound-meters
LHC	lefthand circular
LHCP	lefthanded circular polarization
LO	local oscillator
LSM	Local System Management
LTIP	Long Term Instrument Plan
LTSP	Long Term Science Plan
m	meter
MA	multiple access
M&O	maintenance and operations
Mbps	megabits per second
MHS	Microwave Humidity Sounder
MHz	megaHertz

min	minute
MIMR	Multi-Frequency Imaging Microwave Radiometer
MISR	Multi-Angle Imaging Spectro-Radiometer
MLS	Microwave Limb Sounder
MO&DSD	Mission Operations and Data Systems Directorate
MOA	memorandum of agreement
MODIS	Moderate Resolution Imaging Spectrometer
MOM	Mission Operations Manager
MOPITT	Measurement of Pollution in the Troposphere
M-PDU	Multiplexed Protocol Data Unit
MRC	Master Reference Cube
MRM	Mission Readiness Manager
MRR	Mission Requirements Request
MRTT	Mission Readiness Test Team
MSFC	Marshall Space Flight Center
MTPE	Mission To Planet Earth
N/A	not applicable
NASA	National Aeronautics and Space Administration
Nascom	NASA Communications Network
NASDA	National Space Development Agency (Japan)
NCC	Network Control Center
NCCDS	NCC Data System
NOAA	National Oceanic and Atmospheric Administration
NRT	network readiness testing
NSI	NASA Science Internet
NSIDC	National Snow and Ice Data Center
NSP	NASA Support Plan
ODC	other data center
ODM	operations data message
OM	Operations Manager
OMTPE	Office of Mission to Planet Earth
OPS	operations
OSC	Office of Space Communications
P/B	playback
P/L	payload
PCM	pulse code modulated
PDF	Programmable Data Formatter
PGS	Product Generation System
PI	Principal Investigator
PM	phase modulation
PM	Project Manager
PN	pseudo noise
P&S	planning and scheduling
PSCN	Program Support Communications Network
PSK	phase shift key
QL	quicklook
QPSK	quadrature phase shift key

RA	right ascension
RF	radio frequency
RFI	radio frequency interference
RFSOC	Radio Frequency Simulation Operations Center
RHC	righthand circular
RHCP	righthanded circular polarization
RT	realtime
RTS	relative time sequence
RWA	reaction wheel assembly
RXO	redundant crystal oscillator
S/C	spacecraft
SAD	solar array drive
SAGE III	Stratospheric Aerosol and Gas Experiment III
SBIU	S-band Interface Unit
SCC	spacecraft controls computer
SCF	Science Computing Facility
SDPS	Science Data Processing Segment
SEC	secondary
SE&I	Systems Engineering and Integration
SEQ	sequence
SFE	science formatting equipment
SGLT	Space-to-Ground Link Terminal
SGS	Svalbard Ground Station
SMC	System Monitor Coordination Center
SMS	Structures and Mechanisms Subsystem
SN	Space Network
SOC	Simulation Operations Center
SOM	Science Operations Manager
SOWG	Science Operations Working Group
SPSR	service planning segment replacement
SQPN	staggered quadri-phase PN
SSA	S-band single access
SSIM	spacecraft simulator
SSR	solid state recorder
SSST	solid state star tracker
STDN	Spaceflight Tracking and Data Network
T&DA	tracking and data acquisition
TAM	Three-Axis Magnetometer
TBD	to be determined
TBR	to be resolved
TBS	to be supplied
TCS	Thermal Control Subsystem
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TF	transfer frame
TFEC	transfer frame error correction
TFG	transfer frame generator
TGT	TDRSS Ground Terminal
TL	team leader
TLM	telemetry
TM	team member
TONS	TDRSS Onboard Navigation System

TOO	target of opportunity
TRMM	Tropical Rainfall Measuring Mission
TW	target week
TWT	traveling wave tube
UPD	user performance data
UPS	uninterruptable power supply
UT	Universal Time
UTC	Universal Time Coordinated
V0	Version 0
VAFB	Vandenberg Air Force Base
VCDU	virtual channel data unit
VCHP	Variable Conductance Heat Pipes
VSWR	voltage standing wave radio
W	watt
WFF	Wallops Flight Facility
WSC	White Sands Complex
WSGT	White Sands Ground Terminal
WOTS	Wallops Orbital Tracking Station

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ORGANIZATION/TITLE	RESPONSIBILITIES
Overall Organizational Assignments	The Associate Administrator for the Office of Mission to Planet Earth, NASA Headquarters (Code Y), is responsible for the overall direction and evaluation of the EOS Program. The Associate Administrator has assigned Headquarters responsibility to a management team consisting of the Director, MTPE Flight Systems Division; the Director, Mission Operations, Data and Information Systems Division; and the EOS Senior Project Scientist. Within NASA, GSFC is responsible for project management of the EOS spacecraft, the related ground system, and tracking and data acquisition systems.
GSFC Management Responsibilities and Organization	Within GSFC, the Mission to Planet Earth Office has overall functional responsibility for EOS. The responsibilities are divided into three projects under the Flight Projects Directorate, two under the Mission Operations and Data Systems Directorate, and science activities under the Earth Sciences Directorate (reference the Mission to Planet Earth Organization on page 1064.3).
Director of Mission to Planet Earth	The Director of Mission to Planet Earth is responsible for overall program management, planning, guidance, monitoring, and coordination of EOS activities at GSFC. The incumbent is responsible for coordination across all mission elements including budget planning and control, program-wide schedul management, and reporting. The Director is also responsible for overall mission integration, including assignment of Level 1 requirements responsibility, system management across all mission elements, system-wide interface and configuration coordination, and trade study and system verification planning.
EOS Project Scientist	The EOS Project Scientist, from the Earth Sciences Directorate, is responsible for ensuring the satisfactory accomplishment of the scientific objectives of the mission. The Project Scientist reviews all science planning and implementation activities to ensure that the total mission is consistent with the overall scientific objectives. The Project Scientist evaluates all scientific requirements and provides scientific guidance to the Director of MTPE and others involved in the Program.
EOS AM Project Manager	The EOS AM Project Manager is the senior official at GSFC exclusively responsible for managing execution of the AM project life-cycle. The EOS AM Project Manager has full authority to carry out this responsibility within guidelines and controls prescribed by the Director of Flight Projects, the Directo of the Mission to Planet Earth Office, and the GSFC Director. Specific responsibilities include directing and overseeing the preparation and maintenance of project plans, specifications, schedules and budgets, performing project level Systems Engineering and Integration (SE&I); and reporting project status and contractor performance as required. The EOS AM Project Manager is also responsible for the development of the EOS AM instruments for EOS and other Earth science missions (reference page 1064.4).

Table 1064.1 - Responsibilities for Management (1 of 3)

ORGANIZATION/TITLE	RESPONSIBILITIES
EOS AM Deputy Project Manager	The EOS AM Deputy Project Manager (DPM) is responsible to the EOS AM Project Manager and is an integral member of the management team for the AM Project. The EOS AM DPM supports the EOS AM Project Manager in directing all phases of the EOS AM Project and has Project-wide responsibility for personnel management and for planning and evaluating all EOS AM Project activities on a day-to-day basis. The incumbent provides technical management to the team of technically skilled specialists and their supporting personnel to meet cost and schedule commitments. In the absence of the Project Manager, the DPM assumes full responsibility for the Project.
EOS AM Project Scientist	The EOS AM Project Scientist, from the Earth Sciences Directorate at GSFC, is responsible for ensuring the satisfactory accomplishment of the scientific objectives of the EOS AM-1 mission. The EOS AM Project Scientist reviews the planning and implementation of the EOS AM Project to ensure that the total mission is consistent with the overall scientific objectives. The EOS AM Project Scientist provides leadership in ensuring that the scientific data is used effectively and that the scientific results of the mission are produced expeditiously. The EOS AM Project Scientist evaluates all scientific requirements placed on the EOS AM Project, provides scientific guidance to the EOS AM Project Manager, and provides information and recommendation to the EOS Project Scientist and others involved in the Program. The EOS AM Project Scientist and Program Scientist communicate and coordinate on science issues.
EOS AM Operations Manager	The EOS AM Operations Manager is responsible to the EOS AM Project Manager for the development and coordination of the operations concepts and requirements for the EOS AM-1 spacecraft and instrument and their interfaces to the ground system.
Earth Science Data and Information Systems Associate Director	The Earth Science Data and Information Systems (ESDIS) Associate Director is the senior official at GSFC exclusively responsible for managing execution of the project life-cycle. The ESDIS Associate Director has full authority to carry out the responsibility within guidelines assigned by the Director of Mission Operations and Data Systems, the Director of Mission to Planet Earth, and the GSFC Director. Specific responsibilities include directing and overseeing the preparation and maintenance of project plans, specifications, schedules and budgets; performing project level Systems Engineering and Integration (SE&I); and reporting project status and contractor performance as required. The ESDIS Associate Director discharges the responsibilities with the assistance and support of individuals and organizations assigned either administratively or functionally to the Project (reference page 1064.5).

Table 1064.1 - Responsibilities for Management (2 of 3)

ORGANIZATION/TITLE	RESPONSIBILITIES
ESDIS Deputy Associate Director	The ESDIS Deputy Associate Director is responsible to the ESDIS Associate Director and is an integral member of the management team. The incumbent supports the Associate Director in directing all phases of the Project and has Project-wide responsibility for personnel management and for planning and evaluating all Project activities on a day-to-day basis. The Deputy Associate Director provides technical management to the team of technically skilled specialists and their supporting personnel in order to meet cost, schedule and technical commitments. In the absence of the Associate Director, the Deputy Associate Director assumes full responsibility for the Project.
ESDIS System Management Office Chief	The ESDIS System Management Office Chief is responsible for ensuring that all the subsystems of EOSDIS--namely ECS, EDOS, EBnet, DAAC-unique components, and science algorithms--for each of the versions of EOSDIS are developed, integrated, tested, independently validated and verified, and accepted on schedule to ensure the satisfaction of requirements in support of the ESDIS Project's mission baseline.
EOS Mission Operations Manager	The EOS Mission Operations Manager (MOM) is responsible for development of requirements and management of the portion of the ground system supporting flight operations. After launch,the MOM is responsible for the operation of the spacecraft to fulfill the mission objectives.
Flight Operations Director (FOD)	The AM-1 Flight Operations Director (FOD) works under the direction of the EOS Mission Operations Manager (MOM) and handles the EOS AM-1 flight operations management function throughout the entire EOS AM-1 mission. Prior to launch, this includes defining and leading the process for the development of all spacecraft activation and nominal operations scenarios, and ensuring that the Flight Operations Team is working toward the successful implementation of these scenarios. Post launch, the FOD acts as the principal operations advocate for the EOS AM-1 spacecraft, in a dedicated fashion, for the duration of the mission.
EOS Data Systems Manager	The EOS Data Systems Manager (DSM) is responsible for the acceptance and implementation of mission requirements, the commitment of Code 500 ground system resources, and the integrity of the ground system support for the EOS mission.
Telecommunications and Mission Services Manager, Deep Space Network/Jet Propulsion Laboratory	The DSN Telecommunication and Mission Services Manager is responsible for all DSN support of the EOS Mission project.

Table 1064.1 -Responsibilities for Management (3 of 3)

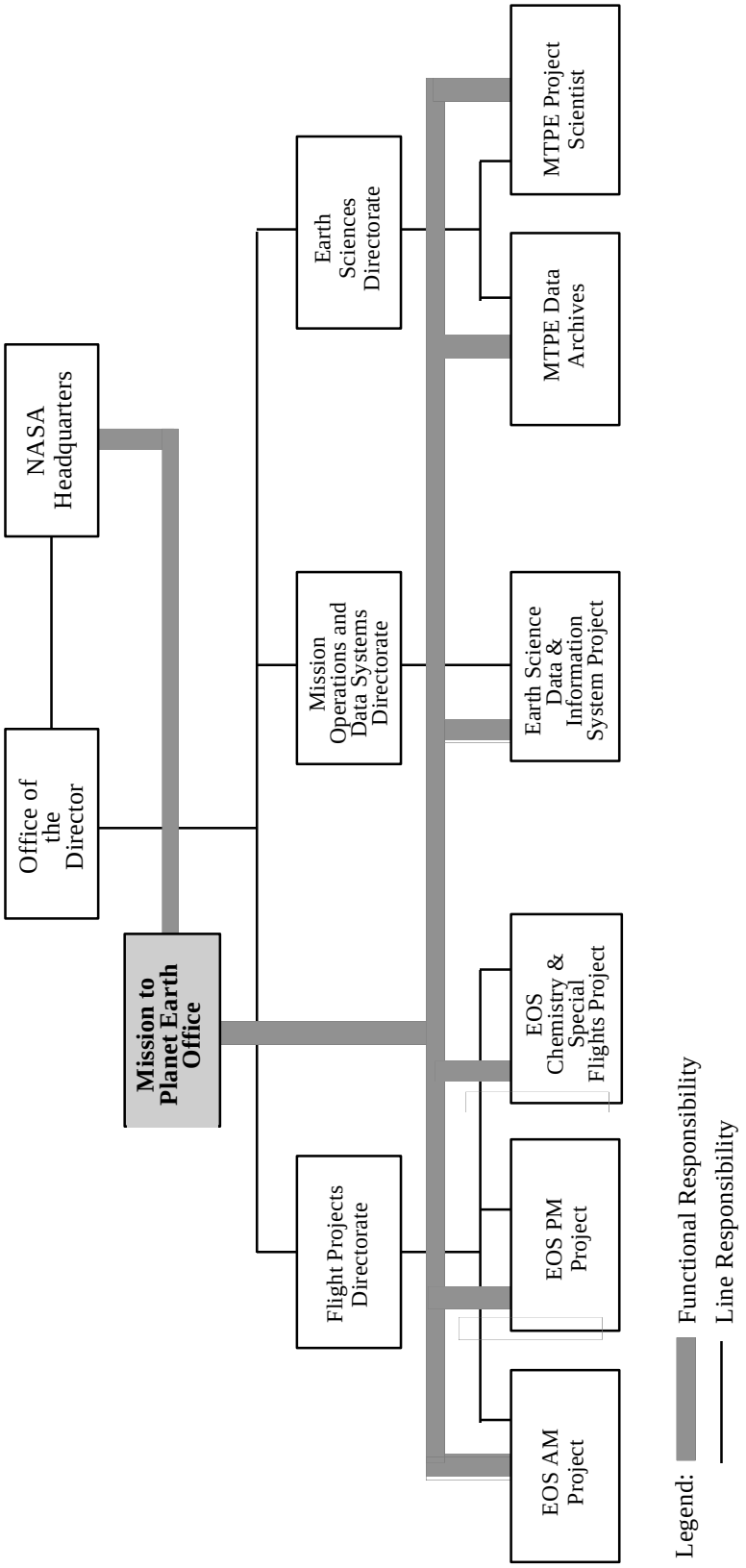

Figure 1064.1 -Responsibilities for Management (1 of 3)

EOS AM Project – Code 421 Organization

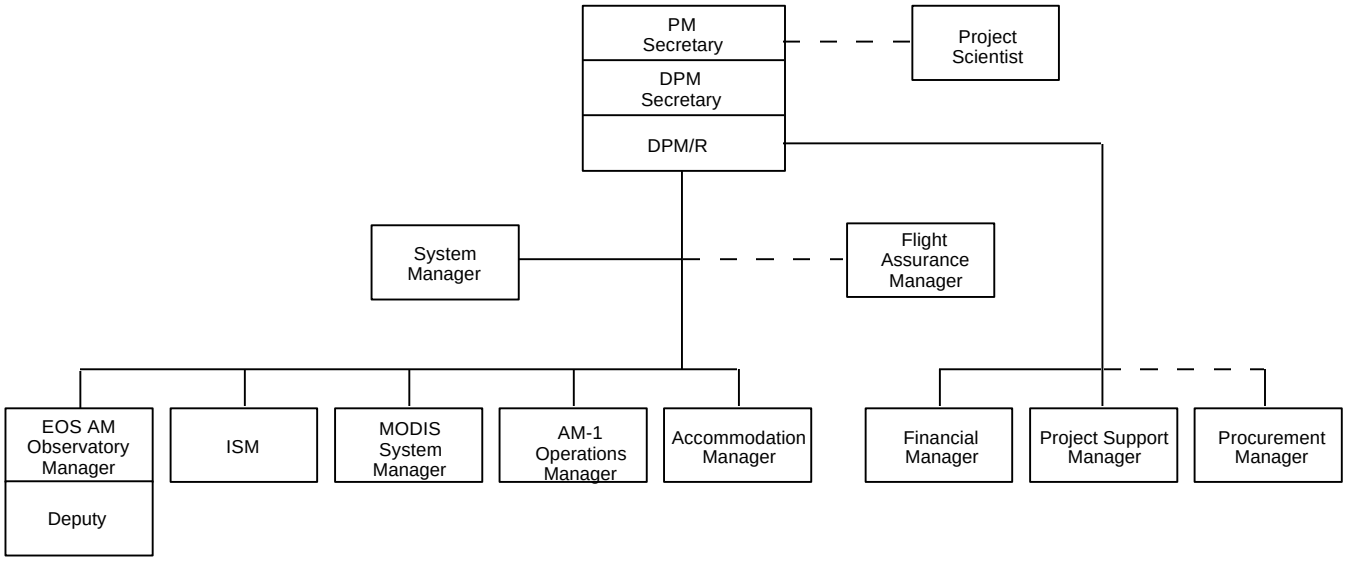

Figure 1064.1 -Responsibilities for Management (2 of 3)

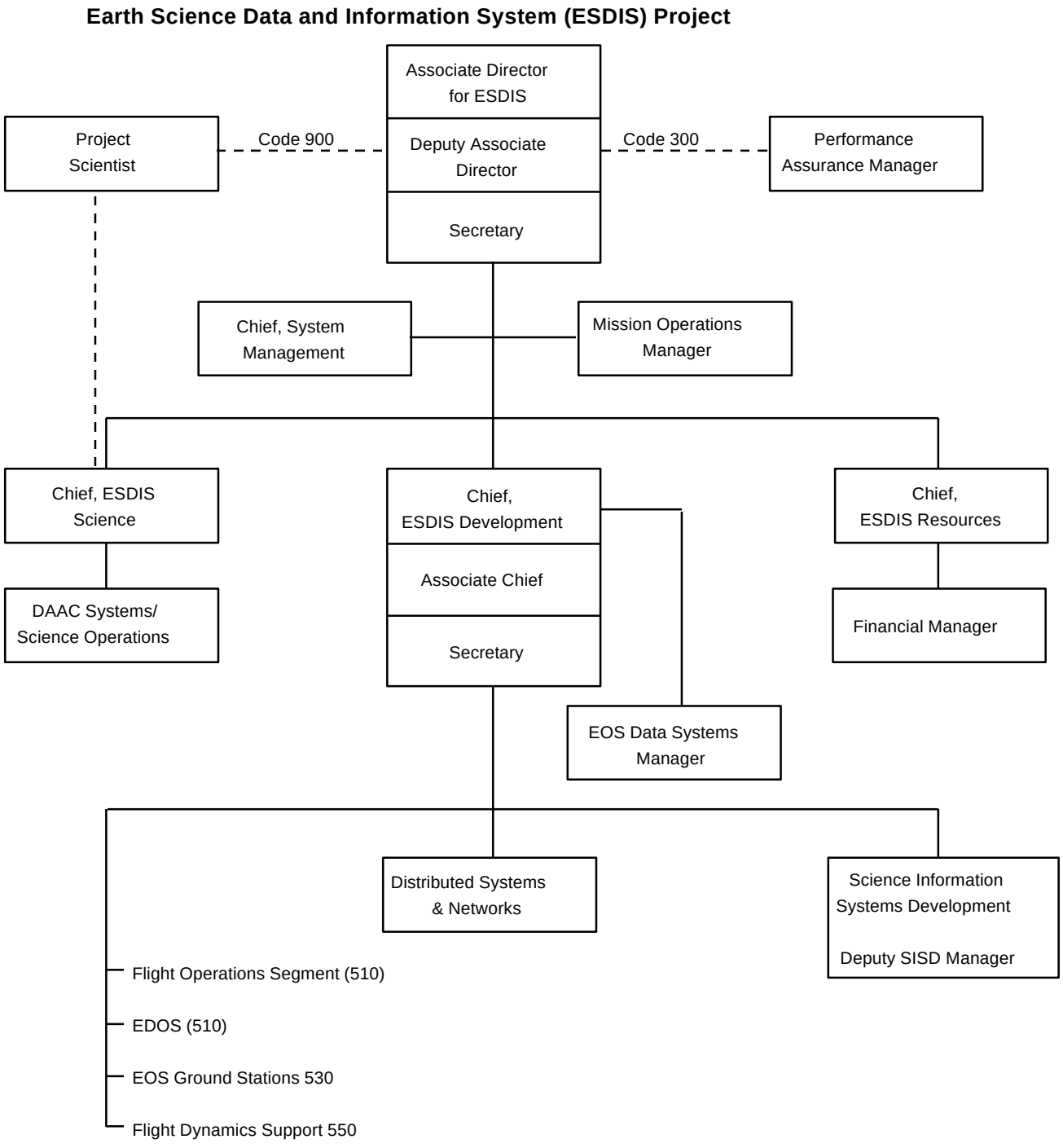

Figure 1064.1 -Responsibilities for Management (3 of 3)

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APPLICABLE AEROSPACE DATA SYSTEM STANDARDS				
	Standard	System Compliance	Deviations	Waivers/Remarks
1.	CCSDS 101.0-B-2 Recommendation for Telemetry Channel Coding	Yes		
2.	CCSDS 201.0-B-1 January 1987 Recommendations for Telecommand, Part 1, Channel Service	Yes		
3.	CCSDS 202.0-B-1 January 1987 Recommendations for Telecommand, Part 2, Data Routing Service	Yes		
4.	CCSDS 202.1-R-3 Recommendations for Telecommand, Part 2.1: Command Operations Procedures	Yes		
5.	CCSDS 203.0-B-1 January 1987 Recommendations for Telecommand, Part 3, Data Management Service	Yes		
6.	CCSDS 301.0-B-1 January 1987 Recommendations for Time Code Formats	Yes		
7.	CCSDS 701.00-B-1 Issue 1, October 1989 Recommendations for Advanced Orbiting Systems, Networks and Data Links	Yes		

Aerospace Data System Standards

Interface Control Document (ICD) 106 Data Format Control Book, Rev. B, September 1996

Radio Frequency (RF) Interface Control Document (ICD) between the EOS AM-1 spacecraft and the STDN (ICD-104), June 1995.

RF ICD between the EOS AM-1 spacecraft and the Wallops Island Station, January 1995.

RF ICD Between the EOS AM-1 Spacecraft and the Wallops Flight Facility X Band Ground Stations (draft, May 1996).

DSN/Flight Project Interface Design Handbook, 810-5, Rev. D, Vol. 1.

EOS AM-1 Spacecraft to Launch Vehicle Interface Control Document (ICD-103).

1100-1

GENERAL DESCRIPTION

EOS is the centerpiece of the National Aeronautics and Space Administration's (NASA's) Mission to Planet Earth (MTPE) program, which is NASA's contribution to the U.S. Global Change Research Program (GCRP). EOS collects data from instruments on several spacecraft in support of disciplines within the Earth science user community. The EOS mission is composed of several series of flights beginning with the EOS AM-1 flight from the AM series in 1998. The other EOS series include PM, LALT (Laser Altimetry), and CHEM (Chemistry) flights. The NASA MTPE missions are complemented by Earth-observing missions sponsored by the International Partners (IPs): the European Space Agency (ESA), the Canadian Space Agency (CSA), and the National Space Development Agency (NASDA) and Ministry of International Trade and Industry (MITI) of Japan. The IPs will supply instruments on EOS flights, and the CSA is also sponsoring two EOS interdisciplinary investigators.

MISSION OBJECTIVE

The EOS mission has the objective of providing the long-term observations and supporting information necessary to develop a comprehensive understanding of the way the Earth functions as a natural system and to support national environmental policy decisions. EOS will provide comprehensive sets of instruments, flying on spacecraft in low-Earth orbit, that will carry out simultaneous observations of the Earth's atmosphere, oceans, and land surface.

This objective will be accomplished through establishment of the following:

- An observing system to provide the full set of essential, global scale Earth science data available from low-Earth orbit on a long-term, sustained basis and in a manner that maximizes the scientific utility of the data and simplifies its analysis.
- A comprehensive data and information system (EOSDIS) to provide the Earth science research community with easy, affordable, and reliable access to EOS data and to other appropriate Earth science data.
- An integrated scientific research program to investigate processes in the Earth system and improve predictive models.

1105-1

The EOS AM-1 is to provide data for the characterization of the terrestrial and oceanic surfaces, clouds, radiation, aerosols, and radiative balance. The EOS AM-1 payload consists of five instruments

- Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)
- Clouds and Earth's Radiant Energy System (CERES)
- Multi-angle Imaging Spectroradiometer (MISR)
- Moderate Resolution Imaging Spectroradiometer (MODIS)
- Measurements of Pollution in the Troposphere (MOPITT)

The instrument complement will provide a 5-year data set on the atmospheric radiative balance and the physical and radiative properties of clouds (ASTER, CERES, MISR, MODIS); high resolution observations of land, ocean, ice surface and cloud processes (ASTER, MISR, MODIS); vertical profiles of important greenhouse gases (MOPITT, MODIS); vegetation structure and dynamics (MISR, MODIS, ASTER); and volcanology (ASTER, MISR, MODIS).

1110-1

The Instrument complement for EOS AM-1 consists of five instruments devoted to the characterization of the terrestrial and oceanic surfaces, clouds, aerosols, and radiative balance. EOS AM-1 will carry two classes of instruments: Facility Instruments (FI) supplied by NASA in response to the general mission, and Principal Investigator (PI) instruments selected through competition and aimed at the specific focused research interests of the selected investigators. These are described in the paragraphs that follow.

ADVANCED SPACEBORNE THERMAL EMISSION AND REFLECTION RADIOMETER (ASTER)

The ASTER instrument is a high-resolution multi-spectral imaging radiometer. The ASTER is a facility instrument (FI) developed by the Ministry of International Trade and Industry (MITI) of Japan provided under a Memorandum Of Understanding (MOU) with the Ministry of International Trade and Industry NASA. The ASTER science objectives include the investigation of land use patterns and vegetation characteristics; evapotranspiration; temporal land-cover classification; volcano monitoring; the study of coral reefs, glaciers and ocean temperatures, surface temperature emissivity and reflectivity; and cloud-top temperature and structure. Dr. Hiroji Tsu of the Geological Survey of Japan is the ASTER science team leader. Dr. A. Kahle of Jet Propulsion Laboratory is the United States science team leader.

CLOUDS AND THE EARTH'S RADIANT ENERGY SYSTEM (CERES)

For AM-1, the CERES instrument, a PI instrument, consists of two scanning radiometers, each with three separate telescope units. When two scanners are flown, this configuration will allow one scanner to operate in the crosstrack mode, for complete spatial coverage from limb to limb--and the other to operate with a rotating scan plane as well as in the crosstrack mode (biaxial) to provide angular sampling. The CERES science objectives are to generate data products that provide cloud-radiative and forcing-feedback inputs to the climate system models- and an observational baseline of clear-sky radiative fluxes and radiative input to atmospheric and ocean energy models. The CERES PI is Dr. B. Barkstrom of NASA Langley.

MULTI-ANGLE IMAGING SPECTRO-RADIOMETER (MISR)

The MISR instrument, a PI instrument, uses nine charge coupled device (CCD) based pushbroom cameras. The MISR science objectives include the study of the climatic and environmental consequences of changes in global aerosols loading, spatial and seasonal variation of different cloud types and their effect on the planetary solar radiation budget; the interactions between biophysical and atmospheric processes; and the detection of changes in the structure, distribution, and extent of the Earth's forests, deserts and cryosphere, and the investigation of climatic implications.The MISR PI is Dr. D. J. Diner of the Jet Propulsion Laboratory.

MODERATE RESOLUTION IMAGING SPECTRORADIOMETER (MODIS)

The MODIS instrument, an FI, is an imaging spectroradiometer. The MODIS science objective is to conduct long-term observations of the Earth - develop an improved understanding of global dynamics and processes occurring on the surface and in the lower atmosphere. The MODIS TL is Dr. V. Salomonson of NASA Goddard Space Flight Center.

MEASUREMENT OF POLLUTION IN THE TROPOSPHERE (MOPITT)

The MOPITT instrument is a four-channel correlation spectrometer with cross-track scanning. The MOPITT is an PI instrument provided under an MOU with the Canadian Space Agency (CSA). The MOPITT science objectives are to measure tropospheric CO and CH4 concentrations and to study how these gases interact with the terrestrial and ocean surface and within atmosphere systems. The MOPITT PI is Dr. J. Drummond of the University of Toronto.

Table 1110.1 illustrates the average data rate for each AM-1 instrument over a two orbit period.

Instrument Acronym and Name		***Average Data Rate (kbps)***
ASTER	*Advanced Spaceborne Thermal Emission and Reflection Radiometer*	*8300*
CERES	*Clouds and Earth Radiant Energy System (2 instruments)*	*10 per instrument*
MISR	*Multi-Imaging Spectro-Radiometer*	*3800*
MODIS	*Moderate-Resolution Imaging Spectrometer*	*6200*
MOPITT	*Measurements of Pollution in the Troposphere*	*25*

Table 1110.1 AM-1 Instrument Data Rates

1130-1

INTRODUCTION

A primary goal of EOS mission operations is to provide usable, standardized, and reliable data products continually to support U.S. and international Earth science research. The goal of mission operations is to manage the spacecraft and the ground system to provide good data for use by the science/user community within the available resources. This goal has two major implications. First, a major operations priority is to ensure the successful launch, configuration, calibration, operation, and safety of each spacecraft. Second, the end-to-end design must incorporate adequate reliability and availability within the space and ground segments to ensure the recovery of usable science data. These requirements necessitate the coordination of various EOS operational elements with existing and future NASA support elements to fully utilize the capabilities of each and provide maximum science return.

EOS MISSION CONCEPT

EOS consists of three major segments:

- Science/User Community
- EOS Space Segment
- EOS Ground Segment

The EOS space segmentprovides new capabilities for remote observations of the Earth; the EOS ground systemmakes the data accessible to the scientific user community; and the user community uses the data derived from EOS to support scientific inquiries and to advise on climate policies. The EOS mission concept is illustrated in Figure 1130.1.

SCIENCE/USER COMMUNITY

EOS operations begin and end with the science/user community. Earth science researchers determine the observations to be made; Instrument Engineering Teams (IETs) build the instruments to collect the data; science teams plan and schedule the use of the instruments; Earth Observing System Data and Information System (EOSDIS) provides mission operations and data processing; and the scientists perform quality assurance on the generated data products. Finally, users analyze the data from the EOS instruments, publish the results, and make recommendations to the global change research community.

EOS SPACE SEGMENT

The EOS space segment consists of a series of predominantly polar-orbiting spacecraft which vary in size and complexity. The AM-1 spacecraft will be launched on an ATLAS IIAS from the Vandenberg Air Force Base (VAFB) in California into a near-circular, sun-synchronous, 705 km orbit at the equator with an inclination of approximately 98 degrees. The descending node-crossing time for the AM-1 spacecraft is approximately 10:30 a.m. The ground tracks of the AM-1 spacecraft orbit repeats every 16 days or every 233 orbit revolutions

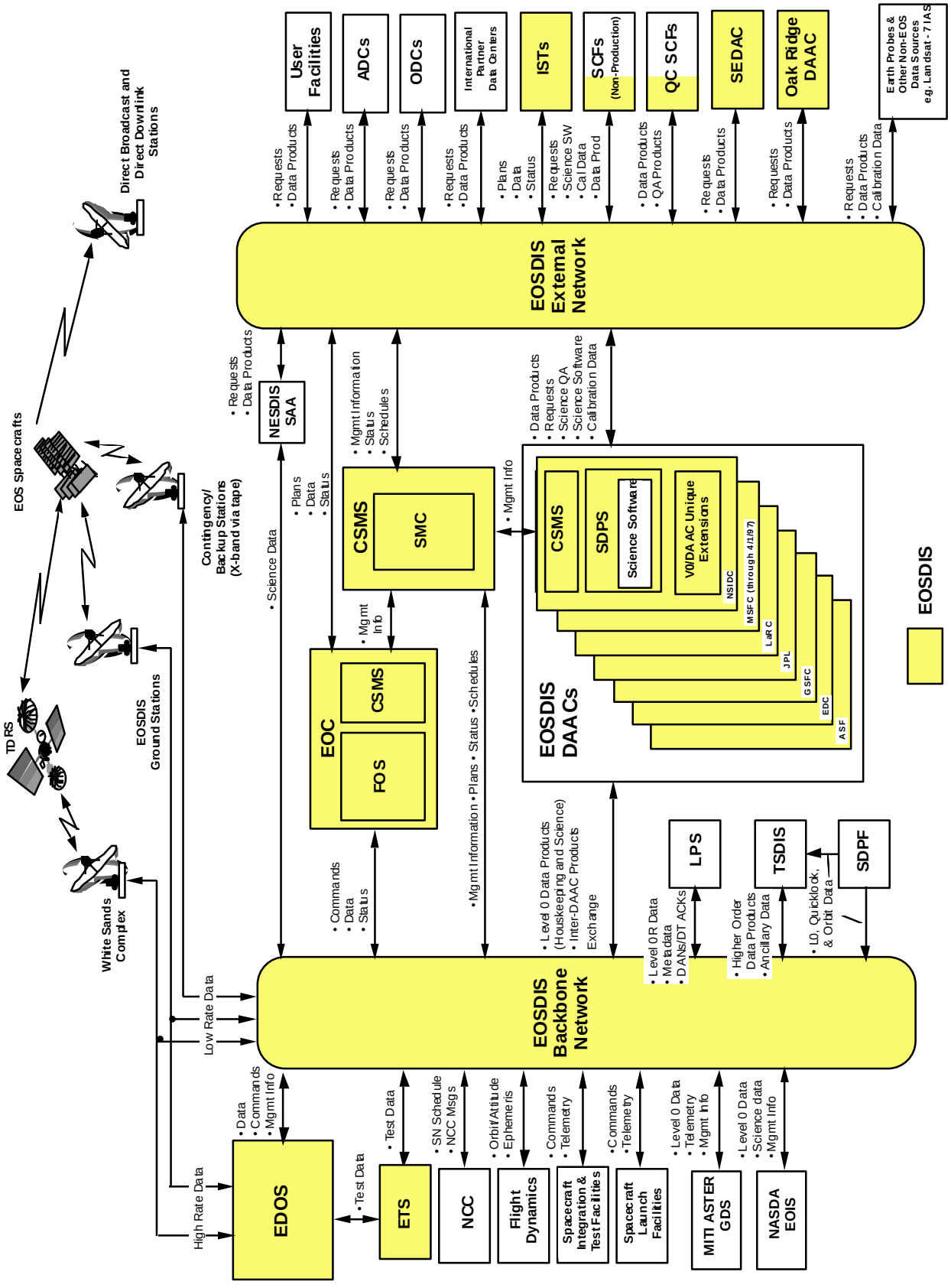


Figure 1130.1 - Mission Operations Concept

EOS GROUND SEGMENT

The EOS ground segment consists of the EOSDIS and NASA Institutional elements.

EOSDIS

EOSDIS will serve as NASA's Earth science data system for information management- and the archival and distribution of related data. EOSDIS will provide command and control, data processing, and data archiving and distribution services for the U.S. EOS spacecraft. Other Earth science missions (e.g., Landsat, TRMM), will utilize the data processing, data archiving, and distribution services as directed by NASA Headquarters.

EOSDIS will provide mission-unique flight operations support and data processing and archiving systems for the EOS mission. EOSDIS consists of

- EOS Data and Operations System (EDOS)
- EOSDIS Backbone Network (EBnet)
- EOSDIS Core System (ECS) and the Distributed Active Archive Centers (DAACs)

EOS Data and Operations System (EDOS)

EDOS provides real-time forward and return link data handling services between the White Sands Complex (WSC) and the EOS Operations Center (EOC) to support command and control and health and safety monitoring functions. EDOS provides a rate buffered service to selected customers, such as the National Oceanic and Atmospheric Administration (NOAA) facility in Maryland. EDOS receives raw science data, as well as housekeeping and engineering data, and performs level zero processing and forwards the Level 0 data to the appropriate DAACs. EDOS archives the Level 0 data for the life of EOS plus 3 years. EDOS is a Code Y funded facility.

EOS Backbone Network (EBnet)

EBnet will provide forward and return link transport services for all EOS operational (mission critical) data. Functionally, the EBnet will provide communications services among the EOS mission critical elements of the ground system. EBnet will, when appropriate, act as an agent for the Earth Science Data and Information System (ESDIS) Project to procure those NASA Communications (Nascom) lines and services required to interface EOSDIS with NASA institutional services, such as the Flight Dynamics Division (FDD) and the Network Control Center (NCC). EBnet is a Code Y funded facility.

EOS Core System (ECS)

The ECS consists of three major segments, all funded by Code Y:

- Flight Operations Segment (FOS)
- Science Data Processing Segment (SDPS)
- Communications and System Management Segment (CSMS)

Flight Operations Segment (FOS)

The FOS consists of the EOC and the Instrument Support Terminals (ISTs) used by the PIs/TLs and their instrument operations teams.

Science Data Processing Segment (SDPS)

The SDPS provides for the generation and maintenance of EOS science data products for distribution to users. It provides the science community with the infrastructure to access EOS science data and to provide products resulting from research activities that use these data. EOSDIS will support user requests for data search and order based on space, time, parameter; metadata and guide info, etc. The SDPS is a distributed system located at several DAACs and provides connection and toolkit service to designated SCFs.

Communications and System Management Segment (CSMS)

Various system-wide services are needed to support each of the geographically distributed elements of the EOSDIS and to support communications to user facilities. The CSMS will provide a focal point for system-wide management of EOSDIS operations through configuration control, high-level scheduling, performance and security management, data accounting/data accountability, and directory and reporting services.

NASA INSTITUTIONAL ELEMENTS

Institutional facilities include SN/TDRSS, Nascom, other networks that will provide alternate space-to-ground links (i.e. WOTS, AGS, and SGS), as well as operational support services from the FDD and the NCC.

Space Network (SN)

The SN will be the primary system for relaying data between the AM-1 spacecraft and the ground and will provide communication resource scheduling to EOSDIS. The SN consists of two main elements: TDRSS and the NCC. TDRSS is comprised of the Tracking and Data Relay Satellites (TDRSs) and the White Sands Complex (WSC) (comprising the White Sands Ground Terminal [WSGT] and the Second TDRS Ground Terminal [STGT]). The NCC serves as the operations center for all SN activities. It is responsible for the scheduling of TDRS and ground terminal operations and the performance of link monitoring and fault isolation functions. Collectively, the SN elements will provide the communications path between the AM-1 spacecraft communications subsystem and EDOS.

TDRSS provides three types of communication services. The first type, a high-rate Ku-band link, will be employed to downlink recorded science and housekeeping data. The second type of service is the S-band Multiple Access (MA) link. This link will be used for navigation, command, and real-time data transmission. The third type of service is the S-band Single Access (SSA) link. This link will also be used for navigation, command, and real-time data transmission. In addition, the SSA will be used to transmit recorded housekeeping data to the ground.

Contingency/Backup Ground Stations

In the event that SNS-band communications become unavailable, due to either spacecraft anomalies, TDRSS anomalies, or scheduling conflicts, WOTS and the EOS AM-1 Backup

Ground Stations at AGS and SGS will be used to link the spacecraft to the EOC to provide command and telemetry support to the AM-1 spacecraft

In the event that SN Ku-band communications become unavailable, due to either spacecraft or TDRSS anomalies, the EOS AM-1 Backup Ground Stations at AGS and SGS will be used to downlink science data from the spacecraft using the onboard X-band antenna. The data will be captured on tapes which will be mailed to EDOS.

Nascom

Nascom lines and services will be procured if necessary by the EBnet Project. Together, EBnet/Nascom will ensure a high level of security for all command, telemetry, and other related information relevant to spacecraft operations.

NASA Flight Dynamics Division (FDD)

The GSFC FDD will provide orbit and attitude computational services and navigation data in support of EOS. Prelaunch services include mission design analysis, trajectory analysis, sensor analysis, and operations planning. Operational support services include onboard orbit and attitude determination validation, anomaly resolution, maneuver planning and support, sensor calibration, and generation of planning and scheduling data products. During routine on-orbit operations, the TDRSS Onboard Navigation System (TONS) will be used for orbit determination on the AM-1 spacecraft. The FDD will perform verification of the TONS' initial and ongoing performance. A large portion of the services provided by the FDD will be performed within the EOC.

EOS AM-1 1310 — Launch Vehicle Description—General

1310-1

The launch vehicle to be used for EOS AM-1 is an Atlas IIAS. It is an intermediate class launch vehicle, capable of delivering an 11,100-pound payload into a polar orbit with a perigee radius of 6929.5 km and an apogee radius of 7070 km.

The launch vehicle requirements are documented in the *EOS AM-1 Spacecraft to Launch Vehicle Interface Control Document (ICD-103).*

1320-1

The spacecraft is conceptually partitioned into well-defined, logically connected subsystems. The subsystems are

- Structures and Mechanisms Subsystem (SMS)
- Propulsion Subsystem (PROPS)
- Thermal Control Subsystem (TCS)
- Electrical Power Subsystem (EPS)
- Electrical Accommodation Subsystem (EAS)
- Guidance, Navigation, and Control (GN&CS)
- Command and Data Handling Subsystem (C&DHS)
- Communication Subsystem (COMMS)

STRUCTURES AND MECHANISMS SUBSYSTEM (SMS)

The SMS structurally supports the instruments, equipment modules, and other spacecraft bus equipment. It provides the overall framework for mounting and positioning the instruments while maintaining precise pointing and alignment. The EOS AM-1 spacecraft structure consists of the primary structure, equipment modules (EMs), equipment panels, instrument accommodation structures, and other secondary structures.

PROPULSION SUBSYSTEM

The EOS AM-1 propulsion subsystem incorporates hydrazine as a monopropellant with catalytic thrusters to provide impulse capability for orbit circularization, orbit maintenance, attitude control, and backup momentum management. Operationally, the subsystem relies on pressure blowdown within a single propellant tank to deliver fuel to a functionally redundant thruster manifold. The subsystem consists of a single 40.6-by-33.8 inch spheroid propellant tank with a maximum capacity of 760 lb (mass), twelve 1-pound attitude control thrusters, four 5-pound delta-V thrusters, two service valves, a pair of latching isolation valves, two filters, and a pressure transducer.

THERMAL CONTROL SUBSYSTEM (TCS)

The EOS AM-1 TCS maintains all spacecraft components and instrument interfaces within allowable thermal limits throughout all spacecraft conditions. The thermal design maximizes the use of passive thermal control techniques such as multilayer insulation (MLI), selective conductance couplings, and selective equipment layout. The TCS also uses selective thermal finishes for various components and structures. For components and equipment with more stringent requirements, the TCS employs active thermal control. A spacecraft provided capillary pumped heat transport system (CPHTS) provides thermal control of the instrument interfaces that cannot reject their heat locally from the instrument. Where required, autonomously controlled heaters ensure that minimum temperature requirements are maintained. Heater control electronics and thermostats provide heater control.

ELECTRICAL POWER SUBSYSTEM (EPS)

The EPS provides all spacecraft instruments and subsystem housekeeping equipment with +120 Vdc ±4% power (at the user) during all mission phases. It provides the functions of energy generation, energy storage, power conversion, regulation, and distribution. Fusing is provided for instruments, power feeds, and heaters. The EPS uses a fully regulated direct-energy-transfer configuration at +120 Vdc, which transfers power directly from the source to the loads with a minimum of losses and without any intermediate power conversion. The EPS provides 5.0 kW end-of-life (EOL) average, of which 2.53 kW is allocated to operate all electrical loads and 2.47 kW is available to recharge the batteries while sunlit. The EPS generates power by a single-wing gallium arsenide on germanium (GaAs/Ge) photovoltaic solar-cell array. The solar array drive (SAD) rotates the solar array to maximize solar exposure. Two rechargeable 50 ampere-hour NiH2 batteries store power for spacecraft operations during eclipse.

ELECTRICAL ACCOMMODATIONS SUBSYSTEM (EAS)

The EAS provides all subsystem and component electrical interconnections and implements the system and major-assembly grounding requirements of the spacecraft. Additionally, the EAS provides electronic assemblies to apply firing current to the electro-explosive devices. These devices are used in the pyrotechnic mechanisms of the solar array and high gain antenna (HGA) deployment systems.

GUIDANCE, NAVIGATION, AND CONTROL SUBSYSTEM (GN&CS)

The GN&CS is an ensemble of sensors, effectors, software, and support hardware that provides control of the spacecraft attitude and orbit following separation from the launch vehicle. In addition, the GN&CS controls the motions of the solar array and HGA relative to the spacecraft. GN&CS primary mode functions are accomplished by a fault-tolerant system that include fault detection, isolation, and recovery (FDIR) capability, using functional and component redundancy. Flight software resident in the C&DHS spacecraft controls computer (SCC) implement most of the GN&CS algorithms.

The GN&CS provides attitude determination and control during all operational phases of the mission. The GN&CS performs attitude determination at the instrument interface to within 90 arcsecs per axis (3-sigma) and pointing control to within 150 arcsecs (3-sigma). It also performs spacecraft position determination to within 150 meters each axis (3-sigma). The EOS AM-1 onboard navigation system primarily uses the TONS for state vector estimation.

The attitude control electronics (ACE) houses the safe mode flight software in the safe hold data processor. The ACE provides control of the spacecraft attitude when control is passed to the ACE from GN&CS software because of anomalous conditions. The ACE takes over control of the primary GN&CS hardware as a result of ground command, SCC command, or upon initiation by "watchdog" circuitry. The circuitry monitors periodic signals from the SCC that indicate continued functional health of the SCC and resident software. During normal conditions, the ACE provides output signal from and command conditioning to the inertial reference unit (IRU), earth sensor assembly (ESA), coarse Sun sensor (CSS), three-axis magnetometer (TAM), reaction wheel assembly (RWA), and magnetic torquer rods (MTRs).

The two solid state star tracker (SSSTs) provide star position and magnitude measurements to the GN&CS software for precise attitude determination. Each SSST is a fixed, nongimbaled sensor

with an 8 degree by 8 degree field of view. Each SSST is capable of tracking five stars simultaneously. Star position is accurate to 10 arcsecs for +2 to +4 MI stars and 16 arcsec for +4 to +5.7 MI stars. The GN&CS software will use the fine Sun sensor (FSS) in the event of an SSST failure. The FSS provides two axis sun position data over a 64 arcsec x 64 arcsec field of view. It is accurate to within 60 arcsec (3-sigma) when the sun is within a 30 degree half cone of the boresight.

The GN&CS interfaces with the PROPS for controlling a set of twelve (six primary and six redundant) attitude control thrusters for backup momentum loading and rate nulling after launch vehicle separation. The GN&CS also commands the PROPS four delta-V thrusters during planned orbit adjust maneuvers.

The COMMS S-band transponder provides Doppler frequency from TDRSS forward link service to the GN&CS. The GN&CS navigation software uses the Doppler data for orbit position and time maintenance. The software uses the orbit information to determine the expected Doppler Shift for a TDRS. The navigation software provides the communications subsystem with the Doppler compensation required for acquisition. The software also provides the Command and Data Handling Subsystem with an estimate of the spacecraft clock bias.

Further information on the GN&C subsystem may be found in "Performance Specification for the GN&C Subsystem, EOS AM-1 Spacecraft, SP-601".

COMMAND AND DATA HANDLING SUBSYSTEM (C&DHS)

The command and data handling subsystem (C&DHS) provides onboard computing resources to accomplish spacecraft control and digital communications. It is responsible for the baseband handling of all uplinked command data transfers received from the COMMS and for coordinating the telemetering of all spacecraft and instrument generated data to be downlinked through the COMMS or hard-lines. The C&DH subsystem is distributed throughout the EOS AM-1 spacecraft with interfaces to all other subsystems and to the instruments utilizing bus data units (BDUs) and remote terminals (RTs).

Redundant SCCs provide control of most spacecraft functions. One SCC is nominally active while the other is powered off in cold-standby mode. However, the spacecraft can operate with both SCCs powered on for diagnostic operations. Each SCC is a MIL-STD-1750A compliant processor. The active SCC hosts a real-time operating system and supports the execution of application software for the spacecraft subsystems and instruments.

The command and telemetry interface units (CTIUs) provide the communication interface for uplinked commands and for housekeeping telemetry. The two CTIUs remain powered when the spacecraft is powered. Both the active and standby CTIU receive uplink commands through the forward link service.

The command and telemetry (C&T) bus provides the onboard communication link between the CTIUs, BDUs, and instruments. The C&T is a redundant serial data bus using a digital time division command/response multiplex data bus (MIL-STD-1553B) protocol. One CTIU acts as the bus controller, while the other CTIU acts as a remote terminal. All other nodes act as remote terminals.

The BDUs are located near instruments and within housekeeping equipment modules. They provide the monitoring and control services to their associated instruments or spacecraft

components. Standardized I/O circuit modules interface the BDUs to sensors, effectors, and other units. The interfaces permit each BDU to send relay drive, serial, and logic pulse commands. The interface also allows the BDUs to sample serial, analog, and bilevel telemetry. The BDUs provide signal conversion and signal conditioning between the analog and digital domains.

The Science Formatting Equipment (SFE) is part of the high-rate data handling system for the EOS AM-1 Spacecraft. The SFE accepts asynchronous data in the form of CCSDS Version-l source packets from both the low-rate science bus (MIL-STD-1553B) and multiple redundant high rate point-to-point electrical links. The SFE then assembles the packets into CCSDS frames. The SFE routes a selectable set of CCSDS frames to a combination of destinations. The destinations include multiple COMMS modulators and the solid state recorder (SSR).

The SSR has a beginning of life data storage capacity of approximately 172 gigabits, of which 1.46 Gigabits (15 orbits) are allocated to housekeeping telemetry for playback through the S-band transponder. The SSR is capable of simultaneously recording and playing back spacecraft science data through an interface with the SFE. Concurrently, the SSR is capable of recording or playing back housekeeping telemetry data through an interface with the CTIU.

COMMUNICATIONS SUBSYSTEM (COMMS)

The COMMS provides all external interfaces for EOS AM-1 data and tracking signals. It receives and demodulates all command data destined for spacecraft subsystems and instruments; modulates and transmits all data from spacecraft subsystems and instruments destined for the ground; and receives, decodes and transmits all signals for spacecraft tracking. The COMMS consists of a 54 inch diameter HGA, S-band Omni antenna system, Ku single access (KSA) modulator, S-band transponder and interface unit, a 4 MHz master oscillator and a Direct Access System (DAS).

The DAS provides X-band real-time transmission of MODIS and ASTER data to user ground stations. The system permits users to receive regional data through two types of services, direct broadcast (DB) and direct downlink (DDL). The DB service accommodates MODIS. The DDL service accommodates real-time data from ASTER. An additional service, direct playback, provides a backup to the TDRSS KSA science data return path in the event of TDRSS non-availability or an HGA catastrophic failure.

1322-1

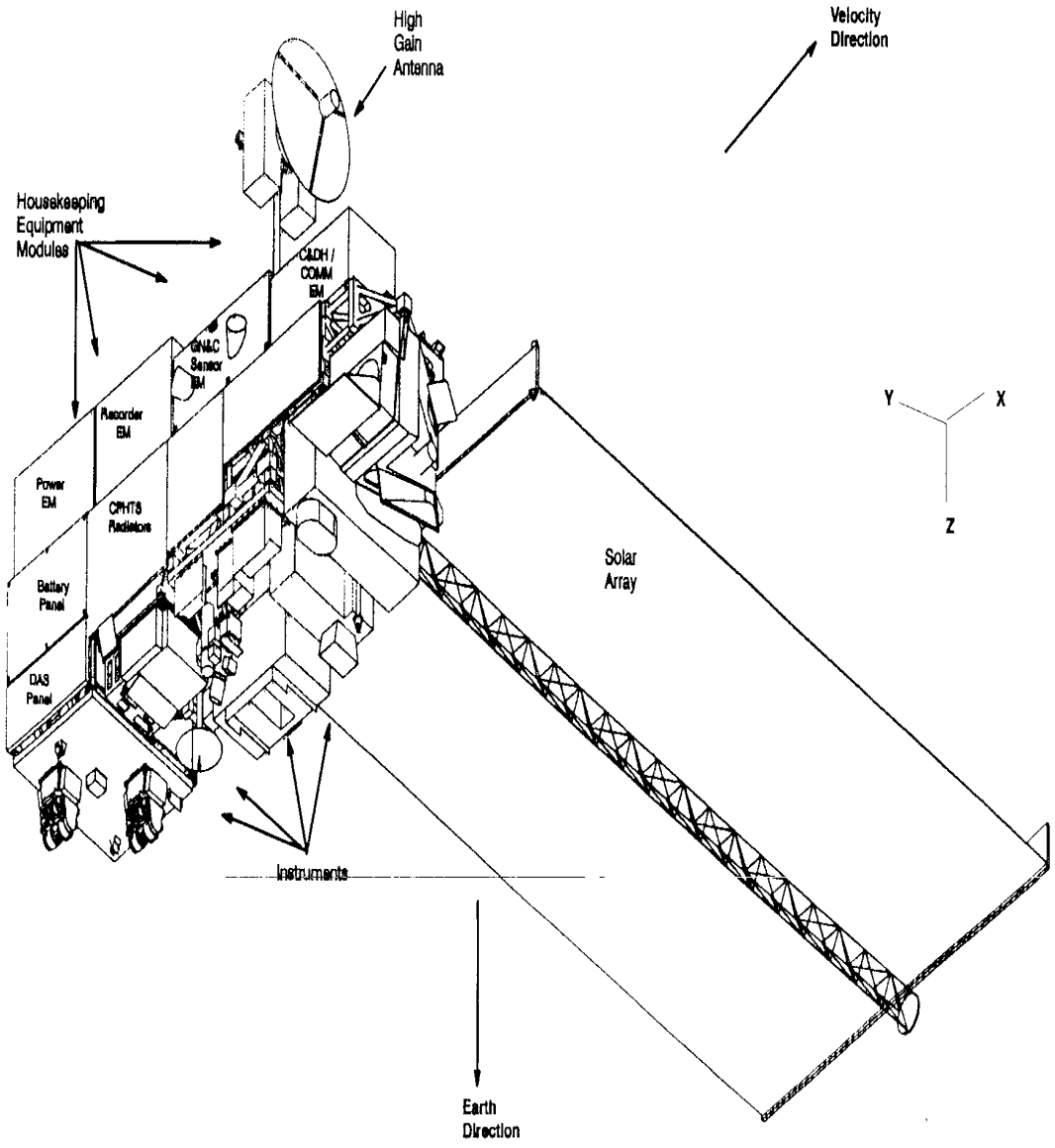


Figure 1322.1 -Spacecraft/Payload Drawing

EOS AM-1 1405 — Frequency Utilization Summary

1405-1

PLANNED FREQUENCIES	MODULATION/ENCODING	DATA RATE	EOS AM-1 ANTENNA	Other Defining Characteristics	SERVICE DESCRIPTION
2106.406250 MHz (± Doppler Shift)	Unbalanced QPSK	10 Kbps 125 bps	HGA (LHC/RHC) Omni (RHC)		TDRSS SSA Forward
	NRZ-M PN on I & Q	1 Kbps	HGA (LHC)		TDRSS MA Forward
2106.406250 MHz 16 kHz ± 0.001% [sinusoidal subcarrier]	PCM/PSK/PM NRZ-M	2 Kbps on subcarrier	Omni (RHC)	Modulation Index = 0.7 Radians	WOTS/ AGS/SGS S-band Uplink
Noncoherent: 2287.5 MHz ±0.1 MHz	SQPSK with PN on I & Q NRZ-M	I: 16 Kbps Q: 16 Kbps	HGA (LHC/RHC)	Rate 1/2 Convolutional Coding	TDRSS SSA Return
Coherent: (exact frequency =240/221 of forward link frequency)	SQPSK with PN on I & Q NRZ-M	I: 1 Kbps Q: 1 Kbps	Omni (RHC)	Rate 1/2 Convolutional Coding	Mode 2 [DG1] (Noncoherent) Mode 1,3 [DG1] (Coherent)
	QPSK with PN on I only NRZ-M	I: 16 Kbps Q: 256 Kbps	HGA (LHC/RHC)	Rate 1/2 Convolutional Coding	Q:I power ratio=4:1
Noncoherent: 2287.5 MHz ±0.1 MHz Coherent: (exact frequency =240/221 of forward link frequency)	SQPSK with PN on I & Q NRZ-M	I: 16 Kbps Q: 16 Kbps	HGA (LHC)	Rate 1/2 Convolutional Coding	TDRSS MA Return Modes 1 & 2 Q:I power ratio=4:1
Carrier: Noncoherent: 2287.5 MHz ±0.1 MHz Coherent: 240/221 x uplink frequency Peak Carrier Phase Modulation (radians): 1.0 ± 5% (rectangular) Subcarrier: 1.024 MHz ± 0.001% Peak Carrier Phase Modulation (radians): 0.8 ± 5%(sinusoid)	PSK/PM NRZ-M Biø-S	16 Kbps PSK on subcarrier only. or 16 Kbps PSK on subcarrier 16 or 512 Kbps on PM carrier	Omni (RHC)	Modulation Index = 1.0 Radian (baseband) 0.8 Radian (subcarrier) No Convolutional Coding	WOTS/ AGS/SGS S-band downlink
15.0034 GHz	Balanced SQPSK NRZ-M	I: 75 Mbps Q: 75 Mbps	HGA (LHC/RHC)	Rate 1/2 Convolutional Coding Data Group 2	TDRSS KSA Return single source (see note 2) Mode 2

REMARKS:
1. HGA: Gain at Ku-band: 42.1 dBi at ± 0.4° Nadir and Zenith Omnis 70% spherical coverage
Gain at S-band (return): 231 dBi at ± 0.4° Gain: -2.1 dBi (transmit), -2.0 dBi (receive)
S-band (forward): 22.1 dBi at ± 0.4°
2. Bits of a single 150 Mbps data stream are alternately modulated on the I&Q channels.

1420-1

The S-Band telemetry system will be utilized to communicate real-time housekeeping, critical health and safety, diagnostic data, and recorder dumps of housekeeping data to the ground systems. Transmission of S-Band telemetry will nominally be supported by TDRSS. In emergency situations, however, theWOTS, AGS, and SGSwill be used. The S-band telemetry system will provide an interface for command and telemetry functions through the launch vehicle umbilical for prelaunch checkout.

Major components of the S-Band telemetry systems are as follows:

a) EOS AM-1 Transponder: The EOS AM-1 transponder will receive telemetry data from the Command and Telemetry Interface Unit (CTIU) and will apply the appropriate coding and signal conditioning for the communications service being used. In the TDRSS mode, the data will be convolutionally encoded (and periodic convolutional interleaved only for the 256 Kbps rate), then QPSK modulated on the return link carrier. In the GN mode, one channel will be BPSK modulated on a 1.024 MHz subcarrier which is then linearly added to the baseband channel and the resultant signal phase modulated on the carrier.

b) The high gain antenna (HGA), the zenith omni antenna, and the nadir omni antenna are connected to the receive side of the transponders at all times. The output of a transponder is selectively configured to a specific antenna.

c) One way forward and one way return (Doppler only) tracking is supported in the EOS AM-1 transponder. Range and two-way Doppler are possible with the coherent operation of the S-band link (see note 2, page 2110). Nominally, one-way Doppler will be used.

d) Master Oscillator (MO): An external MO provides the frequency reference to the transponder transmitter.

e) S-Band Interface Unit (SBIU): RF signal routing between redundant transponders and the spacecraft antennas will be accomplished by the SBIU. Either transponder can be connected to any of the antennas. A switch within the SBIU selects either righthand circular (RHC) polarization or lefthand circular (LHC) polarization for the high gain antenna.

f) S-Band Omni Antennas: The S-Band Omni antennas (both zenith and nadir) are heritage design having flown on DSCS and the Upper Atmosphere Research Satellite (UARS). The omni provides RHC polarization with at least 70% spherical coverage.

g) High Gain Antenna : The HGA provides high-rate TDRSS return link telemetry transmission. The S-band and Ku-Band functions of the HGA are capable of simultaneous operation. The antenna is a 4.5 ft. diameter center fed cassegrain configuration. A Ku-band horn at the cassegrain focal point is separated from an S-band feed at the prime focal point by a dichroic subreflector. The HGA provides RHC and LHC polarization for both S-band and Ku-band communication. The spacecraft will provide a program track (open loop) pointing capability for the HGA using onboard spacecraft computations of TDRSS and EOS position and attitude. The open loop program tracking is via S-band.

Major components of the Ku-band telemetry systems are as follows:

h) KSA Modulator: The KSA Modulator generates the modulated Intermediate Frequency (IF) signal and reference Local Oscillator (LO) for the science data return link through the TDRSS. The KSA modulator functions include channel commutating (i.e., forming two streams of data consisting of alternating bits from a single input), differential encoding, convolutional encoding, IF carrier generation, and staggered-QPSK modulation.

i) High Gain Antenna: The HGA performs the function of TDRSS return link science data transmission at a Ku-band frequency. The upconverter and the TWT will upconvert and amplify the signal.

1421-1

a. S-Band Transponder:

(1) Frequency determining source: Derived from the receiver if operating in the coherent mode (DG1 Mode 1 or 3). Derived from Internal Crystal Oscillator (XO) or external Master Oscillator (MO) if noncoherent (DG1 Mode 2)

(2) RF power: 4.45 watts minimum

(3) TDRSS mode: Channels: I and Q Q/I power ratio: 4:1

(4) GN mode: Biphase S data phase-shift-keyed on a 1.024 Mhz subcarrier, which is then phase-modulated on the S-band carrier

b. Ku-band Modulator:

(1) Frequency determining source: Derived from an oven controlled crystal oscillator

(2) Channels: I and Q

(3) Q/I power ratio: 1:1

(4) RF power: 21 watts maximum, 16 watts minimum

c. Antennas:

(1) Number, type: HGA (1); Omni (2 - zenith and nadir)

(2) Beam, beam width: (see page 1405)

(3) Polarization: HGA (RHC and LHC)
Omni (RHC)

(4) Transmit Gain: (see page 1405)

(5) Estimated passive losses between transponder and HGA:

S-forward link = -1.6 dB

S-return link = -3.9 dB

Ku-return link = -1.8 dB

Estimated passive losses between transponder and omni antennas:

receive = -8.4 dB transmit =-32 dB

1430-1

The S-Band command systems provide for the reception of EOS AM-1 spacecraft commands. Command reception will be primarily supported through the TDRSS, although the WOTS, AGS, and SGS will be used in emergency situations. Command reception capability will also be provided via the launch vehicle umbilical for prelaunch checkout.

The major components of the S-Band telecommunication system are as follows:

a) High Gain Antenna (HGA): The HGA provides communication from TDRSS using the MA and SSA Forward services. See page 1420-1 for a further description.

b) S-Band Omni Antennas: See page 1420-1 for description

c) S-Band Interface Unit (SBIU): The EOS AM-1 transponder receiver interfaces with the spacecraft antennas via the SBIU. Both of the omni antennas and the HGA are passively combined to allow command reception from any antenna by either transponder.

d) Master Oscillator (MO): See page 1420-1 for description

e) S-Band Transponder: In the TDRSS mode, the S-Band transponder receives, despreads, and demodulates the command signals sent to the spacecraft. It also performs doppler extraction on the TDRSS forward link and provides the data to the GN&C Subsystem via the C&DH Subsystem. In addition, it detects the PN code epoch on the TDRSS forward link and provides the time instant when the PN epoch is detected to the C&DH Subsystem for time tagging and spacecraft clock calibration processing.

   In the GN mode, the transponder receives and demodulates the command uplink signal.

   Both transponders pass commands to the Command and Telemetry Interface Unit (CTIU), but the CTIU selects and processes commands from only one of the transponders (the one on which "bit" and "RF" lock and "start sequence detection" first occurs).

1431-1

Command Receiver - TDRSS Mode

(1) Center Frequency (Nominal): 2106.40625 MHz (SSA/MA service)

(2) Command threshold: -138dBm @ 125 bps; -129 dBm @ 1 Kbps; -119 dBm @ 10 Kbps

(3) Acquisition Frequency Range: ± 1500 Hz of actual center frequency with frequency rate of change ≤ 75 Hz/sec (maximum).

(4) Carrier Tracking Range: ± 160 KHz about assigned center frequency

(5) Unbalanced QPSK modulation with I to Q power ratio 10 dB.

(6) Both I and Q channels are PN spectrum spreaded.

Command Receiver - GN Mode:

(1) The subcarrier will phase modulate the carrier

(2) Subcarrier frequency: 16 KHz

(3) Center frequency (nominal) = 2106.406250 MHz ± ground station to EOS AM-1 Doppler Shift.

1715-1

Event	Time	Orbit	Support
Start final countdown	L - 24 hours	-	
Hydrazine propellant initialization	L - 20 min	-	
Go to internal power	L - 5 min	-	
Launch	L	-	
SN SSA return link	L + 7 min	0	SN SSA return link @ 1 Kbps
ELV separation first perigee	L + 14 min	0	
Start rate nulling of all axes	L + 14:03 min	0	FDD monitor
Rate null accomplished. begin roll/pitch acquisition	L + 15 min	0	FDD monitor
Begin solar array hinge deployment	L + 16 min	0	
Solar array hinge deploy complete	L + 18 min	0	
Begin solar array blanket deployment	L + 19 min	0	
Roll/pitch acquisition complete	L + 21 min	0	FDD monitor
Begin yaw axis acquisition	L + 21 min	0	
Earth acquisition complete	L + 30 min (nominal)	0	FDD monitor
Solar array blanket deployment complete	L+ 32 min	0	
Enter first eclipse	L + 40 min	0	
Begin solar array rotation	L + 58 min	0	
Exit eclipse	L + 75 min	1	
Begin HGA deployment	L + 200 min	2	
HGA deployment completed	L + 209 min	2	
S-band link to TDRS established through HGA	L + 240 min	2	SN SSA Return Link @ 16 Kbps
Begin propellant volume calculations	L + 270 min	3	
Uplink EOS AM-1 and TDRS orbital elements	L + 360 min	4	FDD prepare and validatemean elements & deliver to EOC for uplink
Uplink EOS AM-1 and TDRS state vectors	L + 361 min	4	FDD prepare and validate vectors & deliver to EOC for uplink. Also, monitor NAV state vector propagation.

Table 1715.1 - Spacecraft/Payload Major Mission Events (1 of 2)

Event	Time	Orbit	Support
Propellant volume calculations complete	L + 28 hrs 30 min	17	
First delta-V maneuver	L + 72 hrs	46	FDD orbit determination., mass and c.m. location, and maneuver calculations.
Second delta-V maneuver	L + 98 hrs	61	FDD orbit determination., mass and c.m. location, and maneuver calculations.
Third delta-V maneuver	L + 122 hrs		FDD orbit determination., mass and c.m. location, and maneuver calculations.
Fourth delta-V maneuver	L + 146 hrs		FDD orbit determination., mass and c.m. location, and maneuver calculations.
Fifth delta-V maneuver	L + 170 hrs		FDD orbit determination., mass and c.m. location, and maneuver calculations.
Sixth delta-V maneuver	L + 194 hrs		FDD orbit determination., mass and c.m. location, and maneuver calculations.
Initialize navigation system	L + 9 days		FDD navigation system parameters determination
ADAC update filter converged. GN&C normal mode	L + 10 days		FDD verify SCC attitude determination & control.
Begin operational phase	L + 90 days (nominal)		FDD monitor

Table 1715.1 - Spacecraft/Payload Major Mission Events (2 of 2)

1725-1

The following are the orbital parameters for each post separation phase of AM-1:

Injection Orbit

(This information taken from the S/C-ELV ICD, LMA-IRD-95-004, 11 Aug 1995 version)

	Osculating Orbit Parameters at S/C Separation	Nominal Dispersion
Perigee Radius	6930.0 km	+/- 2.5
Apogee Radius	7075.0 km	+/- 7.0
Inclination	98.224 degrees	+/- 0.1
Descending Node (local mean solar time)	10:20-10:40 am	+/- 0.5 minutes

Note: The launch vehicle will have the capability to provide a variable inclination as a function of nodal crossing time. Descending node nominal crossing time may vary from 10:20 to 10:40 AM local mean solar time.

Nominal Operational Orbit

(These are the current FDD generated elements from May 1996)

Mean Elements:

Epoch	6/20/98:16h58m46.466s
Semi-major Axis	7078.1 km
Eccentricity	0.00116
Inclination	98.31 degrees
Argument of Perigee	90.0 degrees
Right Ascension of Ascending Node	242.4 degrees

2000-0

EOS AM-1 communication shall be primarily supported through the TDRSS. During a period of interruption to TDRSS communications support because of a spacecraft malfunction or an anomalous situation, backup command, telemetry, and tracking functions shall be accommodated through the use of the WOTS, AGS, or SGS. Primary onboard navigation functions shall be supported via the use of the TONS. The TDRSS S-Band tracking support function shall be utilized as the backup navigation source. Direct Access Services (Non-OSC) will also be included which will provide direct to user science data and also act as a backup to the TDRSS science data return link function.

To provide the above-mentioned objectives, the EOS AM-1 communications subsystem will contain Ku-Band, S-Band, and X-band equipment. In addition, the EOS AM-1 includes a High Gain Antenna (HGA), a Nadir Omni Antenna, a Zenith Omni Antenna, and a Direct Access System Antenna. The EOS AM transponder (an AM-1 transponder that is compatible with TDRSS and WOTS/AGS/SGS) will be utilized for S-band communications.

The requirements in the section refer to four mission phases that are defined as follows:

1 = Prelaunch
2 = Launch/acquisition (from launch until approximately L+194 hours)
3 = Checkout (from approximately L+194 hours to approximately L+90 days)
4 = Operational

TELECOMMAND:

All EOS AM-1 commands will originate at the EOS Operations Center (EOC). The EOC will transmit Command Link Transmission Units (CLTUs) to the EOS Data Operations System (EDOS). EDOS will provide this baseband data, with clock, to the ground terminals at White Sands for uplink. A TDRSS S-band single access (SSA) service at 10 Kbps will normally be used for commanding. When SSA is not available, an MA service will provide a normal command uplink rate of 1 Kbps. Initial contact with EOS AM-1 (via its omni antenna) will utilize a TDRSS SSA service at 125 bps. This link is also used as a backup and for contingency purposes. In emergency situations, the EDOS will deliver command data to the WOTS/AGS/SGS for uplink at 2 Kbps.

PRIMARY TELEMETRY:

Normally, EOS AM-1 housekeeping telemetry (both spacecraft bus and instruments) will be downlinked by the spacecraft HGA via a TDRSS SSA service at 16 Kbps. Simultaneous downlink of diagnostic dump data may occur at 16 Kbps on the Q-channel of the SSA service. During the early stages of the mission (and later in contingency modes), the EOS AM-1 will utilize a TDRSS SSA service to provide 1 Kbps of critical health and safety (H&S) data (both spacecraft bus and instruments) and diagnostic dump data via its omni antenna. The 1 Kbps H&S data stream will also be generated during the launch and acquisition phase of the mission. Recorded housekeeping telemetry may be played back at 256 Kbps (Q-channel of TDRSS SSA service) by the spacecraft HGA for anomaly investigations.

EOS AM-1 2000— Radio Frequency (RF) Telecommunications Requirements

During normal science operations, all science/engineering data (as well as ancillary and housekeeping data) will be recorded on solid state recorders (SSRs) onboard EOS AM-1 and played back during a TDRSS Ku-band single access (KSA) return service. The capability will also exist to transmit real-time science/engineering data via a TDRSS KSA return service. A single data stream of either playback science/engineering data or real-time science/engineering data may be transmitted at 150 Mbps (KSA), with alternate bits modulated on the I & Q channels (75 Mbps/75 Mbps). The White Sands Complex (WSC) shall recombine the I and Q channels to provide EDOS with a single 150 Mbps data stream. The Space Network (SN) is not required to provide line outage recording for return link data.

Normally, all EOS AM-1 telemetry will be forwarded by the ground terminals at White Sands. In emergency situations, the WOTS AGS/SGS shall forward S-band real-time telemetry and dump data at 16 Kbps and playback telemetry at 512 Kbps

Direct Access Services:

The Direct Access Services provide transmission of science data from selected instruments to user ground stations at X-band frequencies. The Direct Broadcast (DB) service will provide scheduled transmission of MODIS science data. The Direct Downlink (DDL) service will provide real-time data from the ASTER instrument as a scheduled service available to users . An additional X-band service, Direct Playback (DP), will provide a backup to the TDRSS KSA return service in the event of TDRSS nonavailability or a HGA catastrophic failure. The Direct Access Services will always be operated in a manner so as not to cause RF interference with DSN stations.

The EOS AM-1 DP design includes two different modes; the DP only mode (no DB service) at playback rate of 150 megabits/second and a mixed DP/DB mode, where the DP playback rate is 105 megabits/second downlink and the DB service is 13.125 megabits/second. No NASA institutional support is required for DB and DDL services.

Response: Requirements will be met.

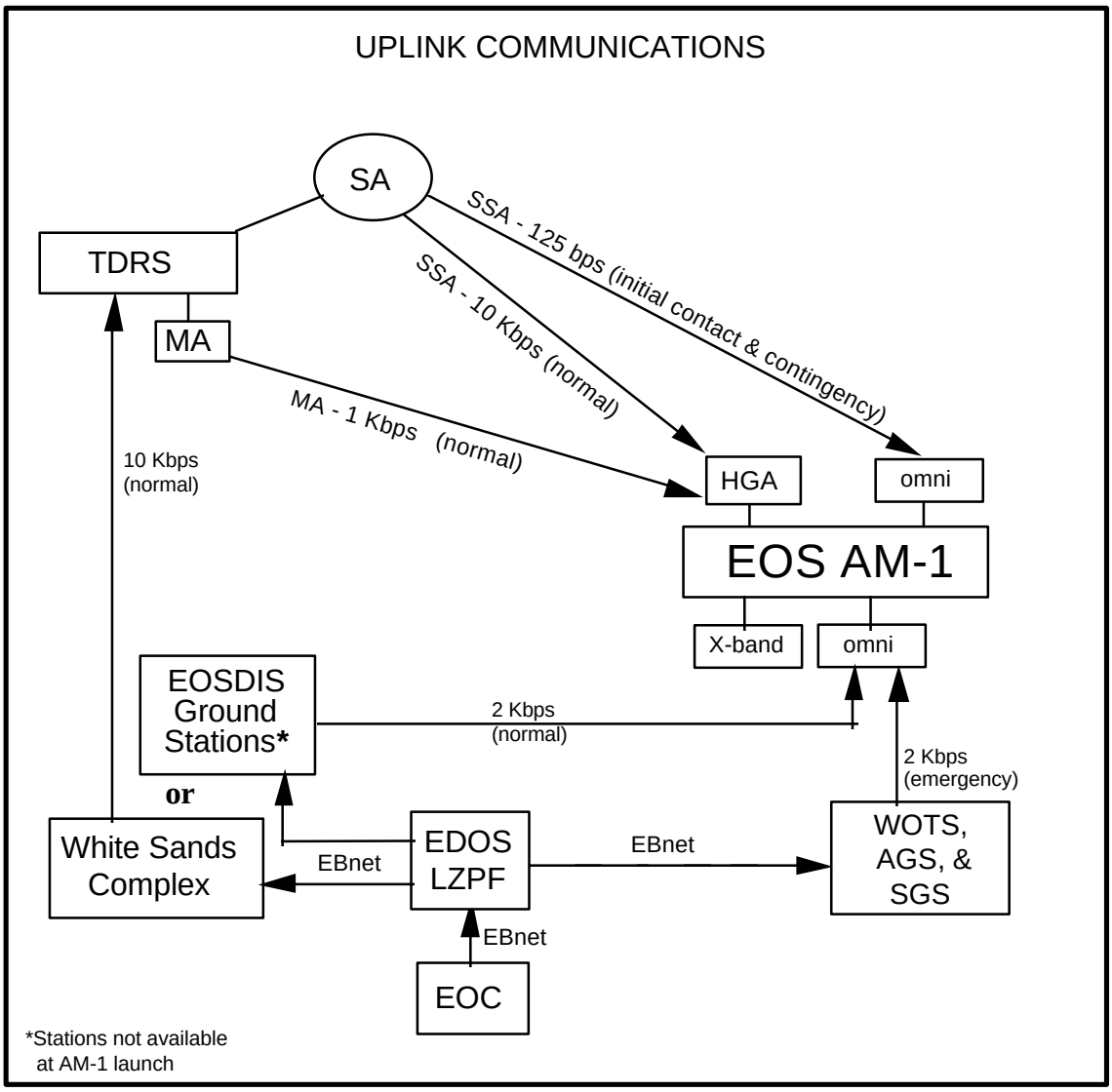


Figure 2000.1 -Radio Frequency (RF) Telecommunications

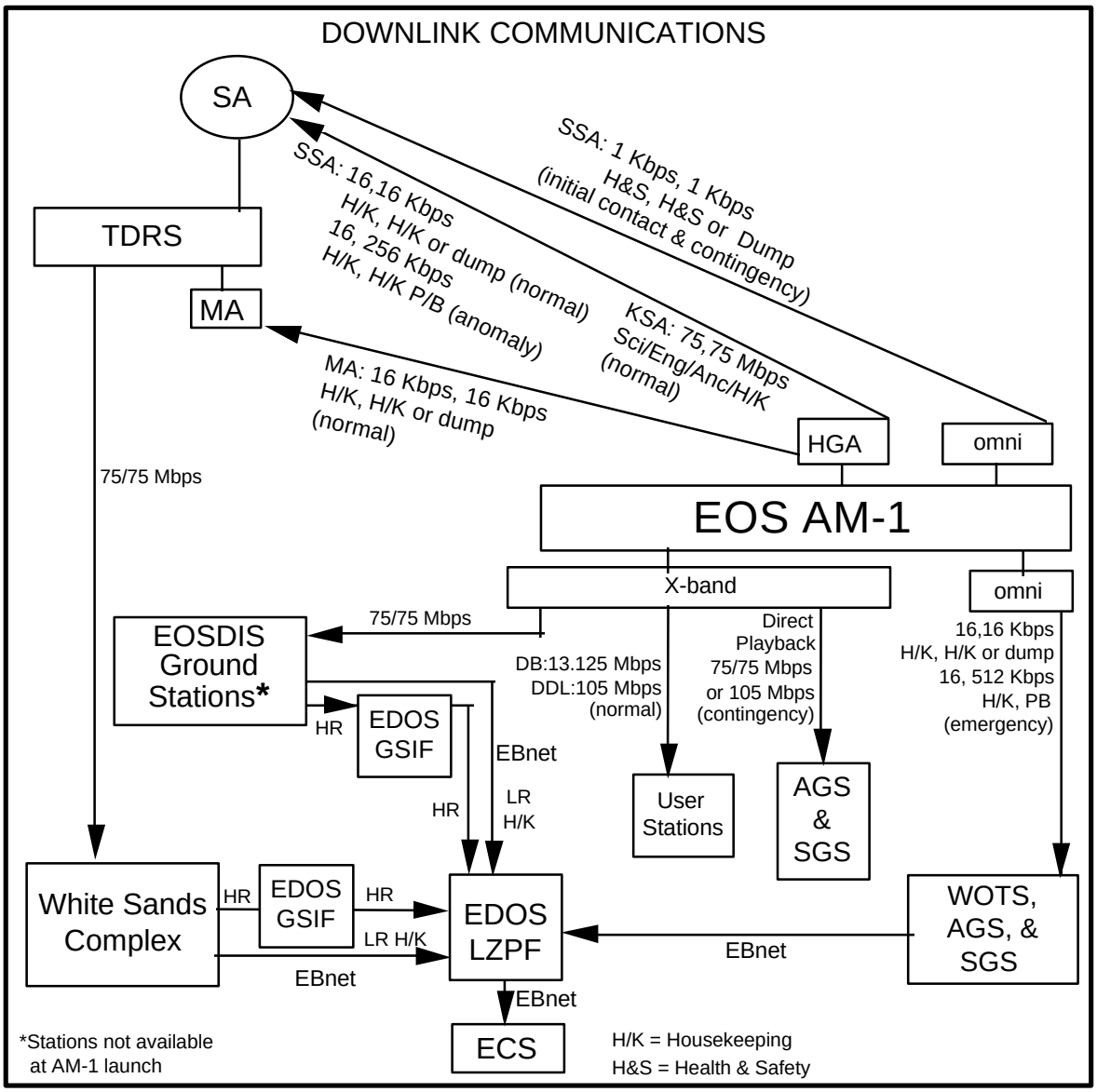


Figure 2000.2 -Radio Frequency (RF) Telecommunications

2005-1

Institutional elements shall support the links listed in Table 2005.1.

FREQUENCY UTILIZATION SUMMARY			
LINK #	XMIT/RCV	Data Rate	Purpose
1	RCV	1 Kbps	Normal low-rate command link (TDRS MA/ EOS AM-1 HGA)
3	RCV	10 Kbps	Normal high-rate command link (TDRS SSA/EOS AM-1 HGA)
5	RCV	125 bps	Backup Commanding and Early Mission Phase (TDRS SSA/ EOS AM-1 Omni)
9	RCV	2 Kbps	Emergency Commanding via WOTS/AGS/SGS (EOS Omni)
2A and 2B	XMIT	16 Kbps/16 Kbps	Routine operations (TDRS MA/ EOS AM-1 HGA) 2A=H/K on I&Q channels 2B=H/K on I channel, Dump/Diagnostic on Q channel
4A and 4B	XMIT	16 Kbps/16 Kbps	Routine operations (TDRS SSA/ EOS AM-1 HGA) 4A=H/K on I channel, H/K on Q channel 4B=H/K on I channel, Dump/Diagnostic on Q channel
4C	XMIT	16 Kbps/256 Kbps	Anomaly - Housekeeping on I channel SSR Playback on Q channel (TDRS SSA/ EOS AM-1 HGA)
6A and 6B	XMIT	1 Kbps/1 Kbps	Contingency and Early Mission Phase (TDRS SSA/ EOS AM-1 Omni) 6A=H&S on I&Q channels 6B=H&S on I channel, Dump/Diagnostic on Q channel
8A and 8C	XMIT	150 Mbps (75 / 75 Mbps Alternating bits)	Science Playback (8a) or Science Realtime (8c) (Single Data Source, TDRS KSA, EOS AM-1 HGA)
10A	XMIT	16 Kbps	Emergency TLM through WOTS/AGS/SGS (EOS AM-1 Omni) 10A = H/K on Subcarrier
10B	XMIT	16 Kbps/16 Kbps	Emergency TLM through WOTS/AGS/SGS (EOS AM-1 Omni) 10B = H/K on Subcarrier, Diagnostic/Dump on Baseband
10C	XMIT	16 Kbps/512 Kbps	Anomaly - Housekeeping on subcarrier, SSR Playback on baseband [via WOTS/AGS/SGS (EOS AM-1 Omni)]

Table 2005.1 -RF Telecommunications Summary Table 1 (of 2)

2005-2

Label	Source	Destination	Data Rate	Channel ID	Purpose
VC-0	EDOS	EOS AM-1 HGA or EOS AM-1 0mni	10 Kbps	I-channel	Normal high-rate command
			1 Kbps	I-channel	Normal low-rate commands
			125 bps	I-channel	Backup commands and early mission commanding
			2 Kbps	subcarrier	Backup commands
VC-1	EOS AM-1 (CTIU)	EDOS	16 Kbps (realtime)	I-channel and Q-channel	Housekeeping Telemetry
			256 Kbps (playback)	Q-channel	
			16 Kbps (realtime)	subcarrier for WOTS/AGS/SGS	
			512 Kbps (playback)	carrier for WOTS/AGS/SGS	
VC-2	EOS AM-1 (CTIU)	EDOS	1 Kbps	1-channel and Q-channel	Critical Health & Safety H/K telemetry
VC-3	EOS AM-1 (CTIU)	EDOS	16 Kbps	Q-channel or carrier for WOTS/AGS/SGS	Diagnostic data
			1 Kbps	Q-channel	
VC-0B	EOS AM-1 (SFE)	EDOS	Variable length packetized data		CERES & MOPITT science/eng packets; plus Ancillary packets and Housekeeping packets
VC-2A	EOS AM-1 (SFE)	EDOS	These virtual channels are contained in the 75/75 Mbps downlink which. is recombined at the TGTs to provide EDOS with a single 150 Mbps data stream.		MODIS Science/eng packets
VC-29	EOS AM-1 (SFE)	EDOS			MISR Science/eng packets
VC-11	EOS AM-1 (SFE)	EDOS			ASTER-Science/eng. packets
VC-12	EOS AM-1` (SFE)	EDOS			ASTER-Science/eng. packets
VC-17	EOS AM-1 (SFE)	EDOS	Playback or Realtime data		ASTER-Science/eng. packets
VC-1E	EOS AM-1 (SFE)	EDOS			ASTER-Science/eng. packets
VC-3F	EOS AM-1 (SFE)	EDOS			Fill CADUs

Remarks: The number following "VC-" in the label column is the hexadecimal representation of the virtual *channel ID.*

Table 2005.1 - RF Telecommunications Summary Table (2 of 2)

Response: Requirement will be met.

2020-1

AM-1 Ku-band, X-band, and S-band space/ground return communications will conform to the Consultative Committee for Space Data Systems (CCSDS) Recommendation for Advanced Orbiting Systems (AOS), Networks and Data Links: Architectural Specification, CCSDS Document Number CCSDS 701.00-B-1, Blue Book Issue-1, dated October 1989. Further information may be found in Interface Control Document (ICD) Data Format Control Book for EOS AM-1 Spacecraft (EOS-02274).

Institutional elements shall support the telemetry frame structure in Figure 2020.1:

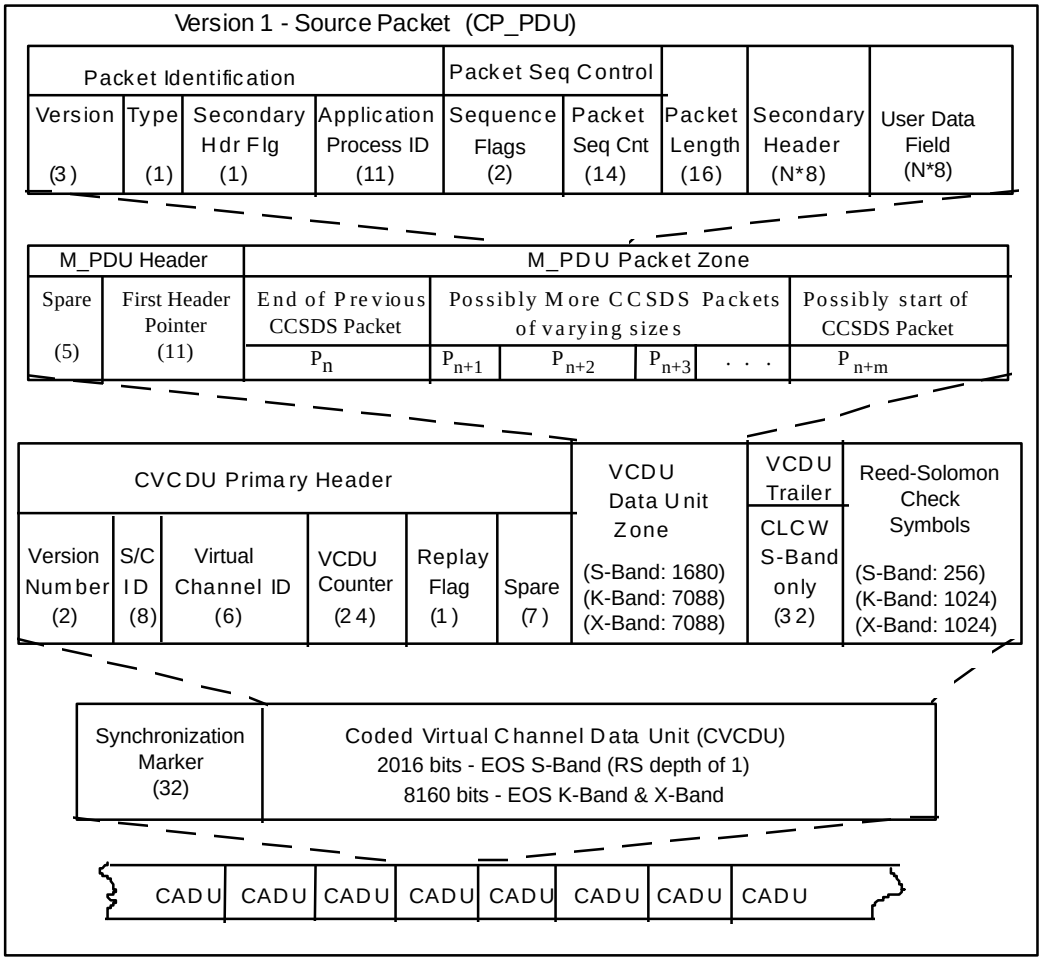


Figure 2020.1 -RF Telecommunications Telemetry Frame

Response: Requirement will be met.

2030-1

AM-1 forward communications will conform to the Consultative Committee for Space Data Systems (CCSDS) Recommendations for Telecommand, Parts 1-3, CCSDS Document Numbers CCSDS 201.0-B-1, 202.0-B-1, and 203.0-B-1, Blue Books, dated January, 1987. Further information may be found in Interface Control Document (ICD) Data Format Control Book for EOS AM-1 Spacecraft (EOS-02274).Institutional elements shall support the telemetry frame structure in the following figure:

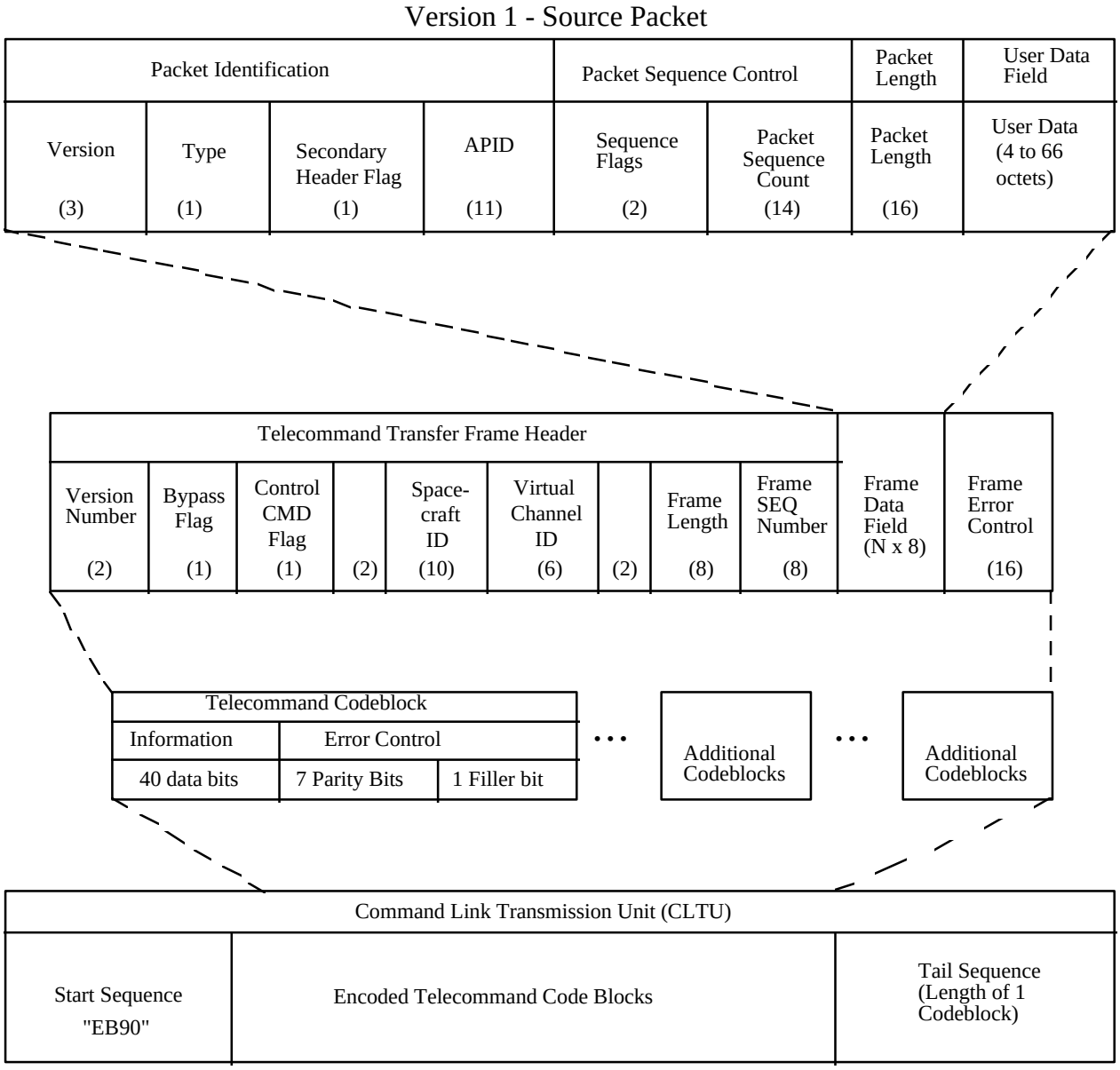


Figure 2030.1 -RF Telecommunications Command

Response: Requirement will be met.

2100-1

The AM-1 spacecraft will utilize the TDRSS SSA, MA, and Ku-band services. The SSA and MA services will be used for navigation, commanding the spacecraft, and the transmission of real-time and recorded housekeeping data from the spacecraft. The high-rate Ku-band service will be used to transmit recorded science and housekeeping data.

The SN shall provide tracking (page 2110), return link communication (page 2120), and forward link communications (page 2130) in support of the AM-1 mission.

Response: Requirementwill be met.

EOS AM-1 2110 — SN - Tracking Requirements

2110-1

The SN shall support the tracking requirements listed in the following table.

SN Tracking Requirements									
No.	Services	Phases (Note 1)	Sample Rate	Frequency of Collection	Duration of Collection	Data Delivery	Media	Destination	Remarks
1	Range	2, 3	1 sample/ 10 secs	See note 3	entire pass	Near Real-time	Electronic	FDD	See note 2
2	Two-way Doppler	2, 3	1 sample/ 10 secs	See note 3	entire pass	Near Real-time	Electronic	FDD	See note 2
3	One-way Return Doppler	2, 3	1 sample/ 10 secs	As required	entire pass	Near Real-time	Electronic	FDD	See note 2
4	Range	4	1 sample/ 10 secs	Once/day	entire pass	Near Real-time	Electronic	FDD	Backup See Note 2
5	Two-way Doppler	4	1 sample/ 10 secs	Once/day	entire pass	Near Real-time	Electronic	FDD	Backup See Note 2
6	One-way Return Doppler	4	1 sample/ 10 secs	2 contacts per orbit (most orbits)	entire pass	Near Real-time	Electronic	FDD	See note 2
7	One-way Forward Doppler	4	Spacecraft determines	2 contacts per orbit	entire pass	Near Real-time	N/A	EOS TONS (see note 4)	Concurrent with forward communication support

Note 1: Mission phases are 1= Prelaunch, 2=Launch/acquisition, 3=Checkout , 4=Operational

Note: 2: During early mission TDRSS tracking support will primarily include coherent, two-way Doppler and range data. One-way return Doppler data may be needed during this early time period. During nominal operations, one pass of one-way return Doppler data per day is needed for local oscillator frequency bias determination as an independent check on the on-board function. Coherent tracking service to provide range and 2-way Doppler data is needed (frequency is typically once per day) for EOC time calibration function. Both non-coherent one-way return and coherent tracking services may be needed as backup capabilities or to provide independent checks of the on-board system as required by the EOC.

Note: 3-. During the Launch/acquisition phase (Phase 2) the FDD will calculate accurate orbit solutions. To achieve this, the SN shall support five to ten scheduled contacts (each approximately 10 minutes in duration) over the first two orbit period.

Note 4: All telemetry values required for TONS ground simulation and evaluation will be included in the 16 Kbps housekeeping stream. EOC will send these values to the FDD.

Response: Requirements will be met

EOS AM-1 2120 — SN - Return Link Requirements

2120-1

The SN shall support the return link requirements listed in the following table.

SN Return Link Requirements									
No.	Service	Phases (note 1)	Data Group /Mode	DATA I Channel	TYPES Q-Channel	Coding	Total Data Rate	Power Ratio	Contact/Orbit (Duration)
1	KSA Return	3, 4	DG2, Mode 2	(Single Data Source with alternate bits on I&Q)	VC-0B, 2A, 29, 11, 12, 17, 1E, 3F	Differential Convolutional Reed-Solomon (interleave depth of 4)	150 Mbps: (75/75)	1:1	2 (12 minutes each) Or equivalent
2	SSA Return	2	DG1/ Modes 1,2,3	VC-1,2	VC-1, 2, 3	Differential Convolutional Reed-Solomon (interleave depth of 1)	272 Kbps: 16/256 16/16 1/1	1:4	See note 4
3	SSA Return	3	DG1/ Modes 1,2,3	VC-1,2	VC-1, 2, 3	Differential Convolutional Reed-Solomon (interleave depth of 1)	272 Kbps: 16/256 16/16 1/1	1:4	See note 6
4	SSA Return	4	DG1/ Modes 1,2,3	VC-1,2	VC-1, 2, 3	Differential Convolutional Reed-Solomon (interleave depth of 1)	272 Kbps: 16/256 16/16 1/1	1:4	2 (12 minutes each) Or equivalent
5	MA Return	3	DG1/ Modes 1,2	VC-1	VC-1,3	Differential Convolutional Reed-Solomon (interleave depth of 1)	32 Kbps: 16/16	1:4	See note 6
6	MA Return	4	DG1/ Modes 1,2	VC-1	VC-1,3	Differential Convolutional Reed-Solomon (interleave depth of 1)	32 Kbps: 16/16	1:4	2 (12 minutes each, whenever SSA is not available) Or equivalent

Note 1: Mission phases are1= Prelaunch, 2=Launch/acquisition , 3=Checkout, 4=Operational

Note 2 and 3: Deleted

Note 4: Continuous SA service shall be required (during line of sight) from separation to approximately L+3 hours. During the remainder of the launch/acquisition phase, two or three 10-30 minute SA contacts/orbit shall be required.

Note 5: The SN is not required to provide Reed-Solomon decoding.

Note 6: During the checkout phase, two 12-minute SSA contacts (or equivalent) per orbit shall nominally be required. In addition, up to five individual (likely spaced out over several weeks) 95-minute (continuous during line of sight) SSA or MA services shall be required.

Response: Requirements will be met.

EOS AM-1 2130 — SN - Forward Link Requirements

2130-1

The SN shall support the forward link requirements listed in the following table

SN Forward Link Requirements						
No.	Service	Phases (note 1)	DATA TYPES	Total Data Rate	Contact/Orbit (Duration)	Remarks
1	SSA Forward	2	VC-0	10 Kbps or 0.125 Kbps	See note 3	
2	SSA Forward	3	VC-0	10 Kbps or 0.125 Kbps	See note 4	
3	SSA Forward	4	VC-0	10 Kbps or 0.125 Kbps	2 (12 minutes each) Or equivalent	
4	MA Forward	2,3,4	VC-0	1 Kbps	MA forward contacts will be scheduled by the FOT whenever sufficient SSA forward support is not available.	During phases 3 and 4, when insufficient SSA Forward support is provided, the FOT will schedule one 5-minute MA forward contact per orbit to ensure the 150 meter each axis (3 sigma) accuracy requirement. Also see note 4.

Note 1: Mission phases are 1= Prelaunch, 2=Launch/acquisition , 3=Checkout , 4=Operational

Note 2: Nominally, Doppler compensation will be inhibited since TONS provides onboard Doppler compensation. In a TONS contingency situations, the EOC will need to perform Doppler Compensation to acquire the S/C, but it must inhibit the compensation for FDD to get the Doppler tracking pass.

Note 3: Continuous SA service shall be required (during line of sight) from separation to approximately L+3 hours. During the remainder of the launch/acquisition phase, two or three 10-30 minute SA contacts/orbit shall be required.

Note 4: During the checkout phase, two 12-minute SSA contacts (or equivalent) per orbit shall nominally be required. In addition, up to five individual (likely spaced out over several weeks) 95-minute (continuous during line of sight) SSA or MA services shall be required.

Response: Requirements will be met.

2140-1 Deleted

2140-2

The Network Control Center (NCC) shall accept TDRSS Service requests and schedule the requested services as able based on priority and available resources. The NCC shall provide real-time monitoring of TDRSS resource performance.

Response: Requirement will be met.

2140-3 Deleted

2140-4 Deleted

2140-5

The NCC shall provide an interface with the EOC as described in requirements 5.1 through 5.7, described below.

2140-5.1

The NCC shall provide the EOC/FOT with a notification of TDRS maneuvers (via a network advisory message) no later than 48 hours before the maneuver.

Response: Requirement will be met.

2140-5.2

To support clock calibration, the NCC shall provide time transfer messages to the EOC.

Response: Requirement will be met.

2140-5.3

The NCC shall (barring catastrophe) provide the EOC/FOT (via a network advisory message) notification of changes to the SGLT (i.e., changes in the association of TDRS spacecraft with TDRSS ground antennas) no later than 48 hours before the implementation of the change.

Response: Requirement will be met.

2140-5.4

The NCC shall provide communications and status of Ground Control Message Requests (GCMRs) to WSC from the EOC.

Response: Requirement will be met.

2140-5.5

The NCC shall provide user performance data (UPDs) in real-time to the EOC.

Response: Requirement will be met.

2140-6 Deleted

2140-7

The TGT shall provide an interface to the EDOS as described in the *Interface Control Document (ICD) between the Earth Observing System (EOS) Data and Operations System (EDOS) and the TDRSS Ground Terminal (TGT).*

Response: Requirement will be met.

2200-1

The DSN shall provide a scheduling interface with the EOC to handle coordination of potential radio frequency interference (RFI) conditions.

Response: Requirement will be met.

EOS AM-1 2400 — WOTS, AGS, and SGS Requirements - Summary

2400-1

Wallops Orbital Tracking Station (WOTS), Alaska Ground Station (AGS), and Svalbard Ground Station (SGS) shall provide emergency support during a period of interruption to TDRSS communications support due to a spacecraft malfunction or an anomalous situation. WOTS, AGS, and SGS shall supply emergency support within 1 hour of an emergency request. WOTS, AGS, and SGS shall provide command, telemetry, and tracking support as summarized on page 2000-1. Specific requirements are stated on pages 2410-2430. Further information concerning the RF interface between the WOTS and the EOS AM-1 spacecraft may be found in the *Radio Frequency Interface Control Document Between the EOS AM-1 Spacecraft and the Wallops Island Station* (EOS-05701).

Response: Requirements will be met.

EOS AM-1 2410 — WOTS, AGS, and SGS- Metric Tracking Requirements

2410-1

The WOTS, AGS, and SGS shall support the metric tracking requirements listed in the following table.

WOTS, AGS, and SGS Metric Tracking Requirements										
No.	Phases (note 1)	Service Type	Sample Rate	Accuracy	Frequency of Collection	Duration of Collection	Data Delivery	Media	Destination	Remarks
1	1,2,3,4	1 way Doppler	1 sample/ 10 secs.	Best Available	Most scheduled passes	Length of pass	Near realtime	Electronic	FDD	
2	1,2,3,4	2-way Doppler	1 sample/ 10 secs	Best Available	As required -see note 3	Length of pass	Near realtime	Electronic	FDD	

Note 1: Mission phases are 1= Prelaunch, 2=Launch/acquisition, 3=Checkout, 4=Operational

Note 2: In requirement No. 1, the carrier frequency is mode 2 (noncoherent) = 2287.5 MHz ±0.001%. In requirement No. 2, the carrier frequency is mode 1 (coherent) = 240/221 times the uplink frequency.

Note 3: Nominally, WOTS, AGS, and SGS radiometric services shall be one-way Doppler using a noncoherent link. However, a situation may arise which shall require the WOTS, AGS, and SGS to provide two-way Doppler using a coherent link.

Response: Requirements will be met.

EOS AM-1 2420 — WOTS, AGS, and SGS- Downlink Requirements

2420-1
The WOTS, AGS, and SGS shall support the return link requirements listed in the following table.

WOTS, AGS, and SGS Return Link Requirements										
No.	Phase (note 1)	Frequency	Modulation Method	Sub-Carrier Frequency	Modulation Index	Data Rate	Data Type	Contact Duration	Contacts per Orbit/ Day	Remarks
1	1,2,3,4	S-Band See note 2	PSK on subcarrier PM on carrier	See note 3	See note 4	Subcarrier: 16 Kbps Carrier: 16 Kbps or 512 Kbps	VC1 and VC3 (see page 2005-1 and 2005-2)	Entire Pass	As needed	

Note 1: Mission phases are 1= Prelaunch, 2=Launch/acquisition, 3=Checkout, 4=Operational

Note 2: The carrier frequency in mode 1 (coherent) is 240/221 times the uplink frequency. The carrier frequency in mode 2 (noncoherent) is 2287.5 MHz ±0.1 MHz.

Note 3: The subcarrier frequency is 1.024 MHz ±0.01%.

Note 4: Peak Carrier Phase Modulation (radians):
- 1.024 MHz real-time telemetry subcarrier: 0.8±5% (sinusoid) - baseband modulation present
- Baseband Modulation:
  (16 Kbps or 512 Kbps Biphase): 1.0±5% (rectangular)

Note 5: Real-time housekeeping data is modulated on the subcarrier. Data modulated on the carrier will be either real-time dump/diagnostic data (16 Kbps) or playback of stored housekeeping data. (See pages 2005-1 and 2005-2).

Note 6: Details of the RF interface may be found in the *EOS AM-1 Spacecraft/Wallops Island Station RF ICD* (EOS-05701).

Response: Requirements will be met.

EOS AM-1 2430 — WOTS, AGS, and SGS- Uplink Requirements

2430-1
The WOTS, AGS, and SGS shall support the uplink requirements listed in the following table.

Wallops Uplink Requirements										
No.	Phase (note 1)	Frequency	Modulation Method	Sub-Carrier Frequency	Modulation Index	Data Rate	Date Type	Contact Duration	Contacts per Orbit/Day	Remarks
1	1,2,3,4	See Note 2	See Note 3	See Note 2	See Note 4	2 Kbps	VC0	Entire Pass	As needed	

Note 1: Mission phases are1= Prelaunch, 2=Launch/acquisition, 3=Checkout, 4=Operational

Note 2: The carrier frequency is 2106.4 MHz plus Doppler Shift. The subcarrier frequency is 16 kHz ± 0.001%.

Note 3: Formatted commands shall be used to Phase Shift Key (PSK) modulate the subcarrier. The modulated subcarrier shall Phase Modulate (PM) the uplink transmitter. The bit modulation of the transmitted carrier shall be NRZ-M.

Note 4: Peak Carrier Phase Modulation (radians): 0.7±10%

Note 5: Details of the RF interface may be found in the *EOS AM-1 Spacecraft/Wallops Island Station RF ICD*

Response: Requirements will be met.

EOS AM-1 2440 — WOTS/AGS/SGS to EDOS Interface Requirements

2440-0

The WOTS, AGS, and SGS shall support the interface requirements governing the exchange of return and forward link data with the EDOS, as described in the *Interface Control Document (ICD) between the Earth Observing System (EOS) Data and Operations System (EDOS) and the Wallops Orbital Tracking Station (WOTS)*

Response: Requirements will be met.

2700-1

During a period of interruption to TDRSS Ku-band communications support due to a spacecraft malfunction or an anomalous situation, the EOS AM-1 backup ground stations at AGS and SGS shall provide X-band data capture and shipment. Specific backup requirements are stated on page 2710. Further information concerning the RF interface between the EOS AM-1 Backup Ground Stations at AGS and SGS and the EOS AM-1 spacecraft may be found in the *Radio Frequency Interface Control Document Between the EOS AM-1 Spacecraft and the Wallops Flight Facility X-Band Ground Stations* (draft, May 1996).

Response: Requirements will be met.

EOS AM-1 2710— Backup Station Science Downlink Requirements (X-Band)

2710-1

The AM-1 spacecraft will use the EOS AM-1 Backup Ground Stations at AGS and SGS to downlink science data if Ku-band operations are unavailable either permanently or for an extended period. During this time, AGS and SGS shall receive and capture the high rate science data at 150 Mbps (75 Mbps / 75 Mbps bit interleaved) The science data tapes shall be shipped to the EDOS for processing. AGS and SGS shall supply science backup support within 1 hour of an emergency request. Note that there is no requirement to support the 105 Mbps downlink rate.
Response: Requirements will be met.

2710-2

Scheduling requests for AM-1 spacecraft support shall receive the highest priority when allocating resources at AGS and SGS. The stations shall capture and record X-band science data for every AM-1 view period, unless directed otherwise by the EOC. The stations shall provide the schedule of station view time to the EOC via an electronic interface.
Response: Requirements will be met.

2710-3

AGS and SGS shall use EDOS-compatible tape recorders to record the X-band science data. The tapes shall be made available for pickup and shipment to EDOS, nominally within 48 hours of data capture. Tapes requiring expedited shipments shall be made available for pickup and shipment as soon as practical after pass completion..
Response: Requirements will be met.

2710-4

AGS and SGS shall provide the capability for the EOC to electronically monitor the progress of the data transmissions. For periods when electronic monitoring becomes unavailable, the stations shall provide a post-pass summary report to the EOC.
Response: Requirements will be met.

2710-5

AGS and SGS shall provide the infrastructure and facilities needed to install, support, and operate EDOS compatible processing equipment
Response: Requirement will be met.

2710-6

To maintain expertise during nominal operations periods, AGS and SGS shall support periodic proficiency exercises. These exercises shall include science data capture, and may include tape shipments to the EDOS, if requested by EOC or EDOS.
Response: Requirements will be met.

EOS AM-1 3000 — Testing and Training Requirements

3000-0

To ensure that all the EOS ground facilities, the spacecraft, and the EOSDIS Ground System (EGS) operations personnel are fully capable of performing the AM-1 mission, a series of simulations, ground system integration tests, and spacecraft tests will be performed. The schedule for the tests is available on the World Wide Web at *http://esdis.gsfc.nasa.gov/integ/schedule.html*

Performance of these tests also provides a substantial portion of the FOT training process through O&M on-the-job training. For a complete description of the EOS Ground System (EGS) Integration and Test (I&T) activities and individual tests, see the EGS I&T Plan in the library at *http://fairmont.ivv.nasa.gov/it* Plans for future EGS Versions will also be placed on this web site.

3000-1

The NASA Institutional elements shall support interface tests to verify that both bulk mission data and control message data can be successfully transferred between: EGS elements and both Institutional elements and External elements over institutional circuits
Response: Requirement will be met.

3000-2

The NASA Institutional elements shall support EGS I&T and the AM-1 EOS Operations Center (EOC) Compatibility Tests (ECTs).
Response: Requirement will be met.

3000-3

The NASA Institutional elements shall support EGS Integration Tests (normally known as Network Readiness Testing) to verify that the end-to-end tracking and data acquisition systems are fully capable of mission support.
Response: Requirement will be met.

3000-4

The NASA Institutional elements shall support simulations and spacecraft tests which provide training to EGS operations personnel. Where possible, these requirements shall be satisfied by tests identified in 3000-1, -2, and -3 above.
Response: Requirements will be met.

3000-5

Deleted.

3000-6

The NASA Institutional elements shall support the AM-1 spacecraft portions of the EGS I&T plan.
Response: Requirement will be met.

3100-1

The NASA Institutional elements shall support interface tests to verify that both bulk mission data and control message data can be successfully transferred between: EGS elements and institutional elements, and EGS elements and external elements over institutional circuits.

Interface tests verify the proper implementation of the communications protocol at the higher levels under both nominal and anomalous conditions. Proper formatting of protocol data units at the application level and any lower levels where custom formats are employed is also verified.

Specific tests and schedules for the interfaces under test are found in the current EGS Version Test Plan located on the WWW at *http://fairmont.ivv.nasa.gov/it.*

Response: Requirement will be met.

3200-1

The NASA Institutional elements shall support EGS I&T and AM-1 joint system tests, such as the AM-1 EOS Operations Center (EOC) Compatibility Tests (ECTs). These tests are performed to ensure that major tracking and data acquisition systems are fully capable of mission support.

Response: Requirement will be met.

3200-2

The NASA Institutional elements shall support the ECTs to check out the RF interfaces of the AM-1 spacecraft telecommunications systems with the nominal, contingency, and backup tracking networks (SN, WOTS, AGS, and SGS).

Response: Requirement will be met.

3200-3

The NASA Institutional elements shall support the ECTs to verify the ability of the EOC to generate commands and process telemetry for the AM-1 spacecraft.

Response: Requirement will be met.

3300-1

The NASA Institutional elements shall support EGS Integration Tests (normally known as Network Readiness Testing) to verify that the end-to-end tracking and data acquisition systems are fully capable of mission support. EGS Integration Tests will include:

1) Functional Threads
2) Performance and Stress Tests

Response: Requirement will be met.

3300-1.1

The NASA Institutional elements shall support the Functional Thread Testing to demonstrate the ability of the integrated EGS system to perform all functions necessary to control and process data from the AM-1 Spacecraft. Functional Thread tests verify the correct implementation of functionality distributed between two or more EGS elements in concert with needed institutional elements.

Response: Requirement will be met.

3300-1.2

The NASA Institutional elements shall support the Performance and Stress Test to verify performance requirements, characterize system response to overload and stress conditions, and provide "end to end" operational tests, including "day in the life" tests that exercise an average day's work over a nominal timeline. The end-to-end or daily operations tests build upon previous functional thread testing, exercising multiple threads simultaneously.

Response: Requirement will be met.

3300-2

The NASA Institutional elements shall support mission readiness testing of the integrated network elements. This shall be accomplished through testing, simulations, and participation in mission end-to-end readiness testing. Tracking and data acquisition (T&DA) support capabilities shall be verified in accordance with test and simulation plans which meet the requirements defined by the EOS Mission Operations Manager (MOM) and Data Systems Manager (DSM).

Response: Requirement will be met.

3400-1

For compatibility testing, the Compatibility Test Van (CTV), Simulations Operations Center (SOC), and Radio Frequency SOC (RFSOC) facilities shall be required to provide test tools necessary for system verification and validation. The RFSOC shall provide a direct TDRS link for SN testing and simulator training. CTV use is not expected to exceed 2 weeks.

Response: Requirements will be met.

3500-0

Training will involve the integrated use of the Institutional elements and their operations personnel to ensure operations readiness of the EGS and supporting personnel. As detailed in sections 3000-3400, operations personnel will support interface testing, compatibility testing, and network readiness testing, which will provide initial training. Where possible, simulations will be conducted in conjunction with spacecraft and/or ground system testing on a non-interference basis and will require no additional Institutional support. In addition to the training received during testing, operations personnel will participate in formal classroom training and operations readiness exercises (simulations). Simulations will be conducted to familiarize operations with the Launch timeline, In-Orbit Checkout, routine operations and contingency operations. Anomaly insertion, detection and correction will occur during these simulations to develop and validate management and operations procedures required for effective handling of contingency situations. Beginning approximately L-6 months, training will concentrate on networks, ground system and spacecraft procedures, and spacecraft familiarization. Simulations and data flows will use the AM-1 spacecraft, SSIM, and ETS as data sources.

Time	Sim Title	Sim Participants	Purpose
L - 6 M to L - 1 M	Mission Ops Sims (S/C)	AM-1 S/C (via rooftop Ant.) EOC, ASTER ICC, EDOS, TDRS, NCC (NTS), FDD, EBnet, Nascom, ISTs, DAACs, SMC, NSI	To use hardware, software, data links and operational procedures for processing commands, telemetry, and science data between the vendor facility, AM-1 spacecraft and EGS components.
L - 6 M to Launch	Mission Ops Sims (ETS)	ETS, RFSOC, EOC, TDRS, NCC (NTS), FDD, EDOS, EBnet, Nascom, ASTER ICC, ISTs, DAACs, SMC, NSI	To use hardware, software, data links and operational procedures for processing commands, telemetry, and science data between ETS and the EGS components.
L - 6 M to Launch	Contingency Site Ops Sims (S-band)	ETS, WOTS, AGS, SGS, FDD, EDOS, EOC, ASTER ICC, ISTs, Nascom, EBnet, NCC, SMC	To use hardware, software, data links and operational procedures for contingency processing of commands and engineering telemetry between the contingency ground sites and EGS components.
L - 6 M to Launch	Backup Science Site Ops Sims (X-band)	WOTS, AGS, SGS, EDOS, EOC, ASTER ICC, ISTs, Nascom, EBnet, NCC, NSI, SMC, DAACs	To use hardware, software, data links and operational procedures for contingency processing of commands, engineering and science data (DDL, DPB) between the contingency X-band sites and EGS components.

Table 3500.1 - Simulations

3500-1

The MO&DSD shall provide formal classroom training to EOS operations staff of Spaceflight Tracking and Data Network (STDN) systems and operations to a level sufficient to perform daily operations with STDN through funding provided by MTPE.

Response: Requirements will be met.

3500-2

The NASA Institutional elements shall support simulations to train EOS operations staff in network operations procedures.

Response: Requirements will be met.

3500-3

The NASA Institutional elements shall support additional training and simulations during the operations phase in order to maintain proficiency in contingency operations procedures, or as necessary due to ground system enhancements.

Response: Requirements will be met.

4000-0

The mission operations center for EOS AM-1 is the EOS Operations Center (EOC). In addition, there is an Instrument Control Center (ICC) located in Japan for the ASTER instrument and Instrument Support Terminals (ISTs) associated with the other instruments. The EOC is a part of the Earth Observing System Data and Information System (EOSDIS). The EOC, ASTER ICC, and ISTs are not Code O funded and their requirements are not covered in this DMRA. An overview of their functions will be given here to show their part in the overall EOS and interfaces which relate to MO&DSD furnished facilities. Code 512 will provide flight software maintenance for the AM-1 spacecraft as indicated in Section 4200.

The EOC performs all EOS spacecraft operations and operations coordination for the instrument complement. EOC functions include overall operations management, spacecraft management, health and safety (H&S) maintenance, spacecraft commanding, instrument command support, and mission planning and scheduling.

For instruments with minimal operational complexity, the EOC conducts instrument operations in coordination with instrument personnel using an IST. A software toolkit will provide IST functionality and allow investigator access to data displays from the EOC. Thus, the IST will have the capability for instrument monitoring and participation in instruments planning and scheduling. The EOC is responsible for instrument H&S for all noncomplex instruments.

The ASTER ICC performs distributed operations planning in conjunction with the EOC and performs instrument command generation, performance monitoring and health and safety analysis and troubleshooting. The ASTER ICC has overall responsibility for ASTER health and safety. The EOC performs high level ASTER H&S monitoring as a backup to the ASTER ICC.

The EDOS is a part of EOSDIS and provides real-time forward and return link data handling services between the White Sands Complex (WSC) and the EOC. EBnet is also a part of EOSDIS and provides forward and return link transport services for all EOS operational (mission critical) data. The overall function of EBnet is to provide the mission critical network services for EOS. Mission critical communication networks provide the dedicated transport of operational data required for command and control of the EOS spacecraft and the transport of Level 0 data sets to the DAACs and appropriate gateways.

The SN, WOTS, AGS, and SGS interface with the EOC through the EDOS and EBnet. This interface handles the command and telemetry data flows. The NCC has a network planning interface with EOC The interface between the FDD and EOC is provided by EBnet/Nascom for data transfer related to the FDD mission planning products and orbit and attitude analysis.

The ASTER ICC interface to the EOC is provided by EBnet. The ASTER ICC will interface with the EOC for AM-1 planning and scheduling, ASTER commanding (using mnemonics with a database located at the EOC), and other operational functions. Real-time instrument telemetry data is delivered by EBnet to the gateway for pickup by the ASTER Ground Data System (GDS).

4200-1

The development of the AM-1 flight software is the responsibility of the spacecraft contractor. Code 512 shall provide Independent Verification and Validation of the flight software during the spacecraft prelaunch phase.

Response: Requirement will be met.

4200-2

Ninety (90) days after launch, Code 512 shall maintain the flight software in accordance with the MOU Between the EOS AM Project and the Flight Software Systems Branch for EOS AM Spacecraft Bus Flight Software Maintenance.

Response: Requirement will be met.

5000-0

The EBnet Project has overall responsibility for meeting all "mission critical" operations communications requirements (voice and AM-1 data) for the EOS Mission. When appropriate, EBnet will act as an agent for the ESDIS Project to procure lines and services that are required to interface EOSDIS with NASA Institutional Services such as the NCC and the FDD.

EBnet/Nascom will provide the communications interfaces between EOC and the NCC, and between the EDOS and the WOTS/AGS/SGS. Other communication interfaces required to support AM-1 spacecraft operations, including command and telemetry interfaces, and which are not listed in these sections will be provided by EBnet and funded through Code Y. EBnet/Nascom will ensure a high level of security for all command, telemetry and other related information relevant to spacecraft operations. EBnet/Nascom requirements during the pre-launch, launch, and mission phases are summarized below and listed on pages 5100-1 and 5150-1. A communications diagram is provided in Figure 5155.1.

5000-1

Nascom shall provide data communications from integration and test through operations phases, including:

- EOC key interface testing
- End-to-end testing
- Operational readiness testing
- Launch
- On-orbit checkout and normal orbital phases

Response: Requirement will be met.

5000-2

Nascom shall provide all interfaces between the EOC and the NCC to transfer TDRSS scheduling requests, the resulting active schedule, User Performance Data (UPDs) and Ground Control Message Requests (GCMRs).

Response: Requirement will be met.

5000-3

Nascom shall provide all interfaces between the EOC and the FDD to transfer real-time and playback spacecraft orbit and attitude data to FDD and provide the EOC with FDD planning aids and orbit and attitude validation.

Response: Requirement will be met.

5000-4

Nascom shall provide interfaces between the EDOS and the WOTS, AGS, and SGS to transport spacecraft commands and receive housekeeping telemetry.

Response: Requirement will be met.

5000-4.1

Nascom shall provide voice interfaces between the EDOS and the WOTS.

Response: Requirement will be met.

5000-5

Nascom shall provide an interface between the FDD and the WOTS, AGS, and SGS to transfer acquisition data from FDD to the ground stations.

Response: Requirement will be met.

5000-6

Nascom shall provide an interface between the FDD and the WOTS, AGS, and SGS to transfer radiometric data from the ground stations to the FDD.

Response: Requirement will be met.

5000-7

Nascom shall provide voice communications from the EOC to the FDD, NCC, EBnet, WOTS, EDOS, ASTER ICC/JPL Gateway, Valley Forge, and Vandenberg Air Force Base (VAFB) during the prelaunch phase.

Response: Requirements will be met.

5000-7.1

Nascom shall provide voice communications from the EOC to the FDD, NCC, EBnet, WOTS, EDOS, and ASTER ICC/JPL Gateway during the launch and mission phases.

Response: Requirements will be met.

5000-8

Nascom shall provide an interface between the FDD and the NCC to transfer acquisition data from FDD to the NCC.

Response: Requirements will be met.

5000-9

Nascom shall provide an interface between the EDOS and the NCC to transfer status and average data rate information.

Response: Requirement will be met.

5000-10 Deleted

5000-11 Deleted

5000-12

Nascom shall provide connectivity between the WSC and the EDOS to transfer command, telemetry, and other related information relevant to spacecraft operations.

Response: Requirement will be met.

5100-1

Item No.	Terminals (Comm. Paths Req'd Between) A	B	Type Comm Req'd	Capa-bility 1 Way or 2 Way	Data Data Source	Source Data Rate	Delivery Time	Ref'd Page	Service Date(s) & Duration	Req. Class
1.1	*EOC*	*NCC*	*Data*	*2W*	*Schedule, Requests/ Results, messages*	*N/A*	*RT*		*L-18 mos to Launch*	*1*
1.2	*EOC*	*NCC*	*Data*	*2W*	*UPDs & GCMRs, Network Status*	*N/A*	*RT*		*L-18 mo to Launch*	*1*
1.3	*EOC*	*FDD*	*Data*	*2W*	*Orbit/Attitude Data From EOC*	*N/A*	*RT*		*L-18 mo to Launch*	*1*
1.4	*EOC*	*FDD*	*Data*	*2W*	*Planning Aids Orbit/Attitude Validation*	*N/A*	*NRT*		*L-18 mos to Launch*	*1*
1.5	*FDD*	*NCC*	*Data*	*1W*	*Acquisition Data*	*N/A*	*NRT*		*L-18 mo to Launch*	*1*
1.6	*Deleted*									
1.7	*Deleted*									
1.8	*EDOS*	*WOTS, AGS, SGS*	*Data*	*2W*	*S/C Commands/ H/K Data*	*2 kbps/16, 512 kbps*	*RT*		*L-14 mo to Launch*	*1*
1.9	*WOTS, AGS, SGS*	*FDD*	*Data*	*2W*	*Radio Metric/ Acquisition*	*N/A*	*NRT*		*L-14 mo to Launch*	*1*
1.10	*EDOS*	*NCC*	*Data*	*2W*	*Status/Average Data Rate Information*	*N/A*	*RT*		*L-14 mo to Launch*	*1*
1.11	*Deleted*									
1.12	*Deleted*									
1.13	*WSC*	*EDOS*	*Data*	*2W*	*S/C Command/ H/K Data*	*1/10 Kbps/ 16/256*	*RT*		*L-15 mo to Launch*	*1*

Figure 5100.1 Data Transport Requirements (Launch and Prelaunch) (1 of 3)

Item No.	Terminals (Comm. Paths Req'd Between) A	B	Type Comm Req'd	Capa-bility 1 Way or 2 Way	Data Data Source	Source Data Rate	Delivery Time	Ref'd Page	Service Date(s) & Duration	Req. Class
2.0	*FDD*	*NCC*	*Voice*	*2W*		*N/A*			*L-18 mo to Launch*	*1*
2.1	*EOC*	*WOTS*	*Voice*	*2W*		*N/A*			*L-18 mo to Launch*	*1*
2.2	*EOC*	*NCC*	*Voice*	*2W*		*N/A*			*L-18 mo to Launch*	*1*
2.3	*Deleted*									
2.4	*EOC*	*FDD*	*Voice*	*2W*		*N/A*			*L-18 mo to Launch*	*1*
2.5	*Deleted*									
2.6	*EOC*	*EDOS*	*Voice*	*2W*		*N/A*			*L-14 mo to Launch*	*1*
2.7	*Deleted*									
2.8	*EOC*	*EBnet*	*Voice*	*2W*		*N/A*			*L-14 mo to Launch*	*1*
2.9	*EOC*	*ASTER ICC*	*Voice*	*2W*		*N/A*			*No earlier than ECT3 to Launch*	*1*
2.10	*ASTER ICC*	*EDOS*	*Voice*	*2W*		*N/A*			*No earlier than ECT3 to Launch*	*1*

Figure 5100.1 Data Transport Requirements (Launch and Prelaunch) (2 of 3)

Item No.	Terminals (Comm. Paths Req'd Between) A	B	Type Comm Req'd	Capa-bility 1 Way or 2 Way	Data Data Source	Source Data Rate	Delivery Time	Ref'd Page	Service Date(s) & Duration	Req. Class
2.11	*Deleted*									
2.12	*Deleted*									
2.13	*Deleted*									
2.14	*Deleted*									
2.15	*Deleted*									
2.16	*EDOS*	*NCC*	*Voice*	*2W*		*N/A*			*L-18 mo to Launch*	*1*
2.17	*EDOS*	*WSC*	*Voice*	*2W*		*N/A*			*L-18 mo to Launch*	*1*
2.18	*Deleted*									
2.19	*Deleted*									
2.20	*EDOS*	*WOTS*	*Voice*	*2W*		*N/A*			*L-18 mo to Launch*	*1*
2.21	*Deleted*									
2.22	*EOC*	*Valley Forge, PA*	*Voice*	*2W*		*N/A*			*L-24 mo to L-3*	*1*
2.23	*EOC*	*VAFB*	*Voice*	*2W*		*N/A*			*L-6 mo to Launch*	*1*

Figure 5100.1 Data Transport Requirements (Launch and Prelaunch) (3 of 3)

Response: Requirements will be met.

5150-1

Item No.	Terminals (Comm. Paths Req'd Between) A	B	Type Comm Req'd	Capa-bility 1 Way or 2 Way	Data Data Source	Source Data Rate	Delivery Time	Ref'd Page	Service Date(s) & Duration	Req. Class
1.1	*EOC*	*NCC*	*Data*	*2W*	*Schedule, Requests/ Results, Messages*	*N/A*	*RT*		*Launch to EOL*	*1*
1.2	*EOC*	*NCC*	*Data*	*2W*	*UPDs & GCMRs, Network Status*	*N/A*	*RT*		*Launch to EOL*	*1*
1.3	*EOC*	*FDD*	*Data*	*2W*	*Orbit/Attitude Data From EOC*	*N/A*	*RT*		*Launch to EOL*	*1*
1.4	*EOC*	*FDD*	*Data*	*2W*	*Planning Aids O/A Validation*	*N/A*	*NRT*		*Launch to EOL*	*1*
1.5	*FDD*	*NCC*	*Data*	*1W*	*Acquisition Data*	*N/A*	*NRT*		*Launch to EOL*	*1*
1.6	*Deleted*									
1.7	*Deleted*									
1.8	*EDOS*	*WOTS, AGS, SGS*	*Data*	*2W*	*S/C Commands/ H/K Data*	*2 kbps/16, 512 kbps*	*RT*		*Launch to EOL*	*1*
1.9	*WOTS, AGS, SGS*	*FDD*	*Data*	*2W*	*Radio Metric/ Acquisition*	*N/A*	*NRT*		*Launch to EOL*	*1*
1.10	*EDOS*	*NCC*	*Data*	*2W*	*Status/Average Data Rate Information*	*N/A*	*RT*		*Launch to EOL*	*1*
1.11	*Deleted*									
1.12	*Deleted*									
1.13	*WSC*	*EDOS*	*Data*	*2W*	*S/C Commands/ H/K Data*	*1/10 Kbps/ 16/256*	*RT*		*Launch to EOL*	*1*

Figure 5150.1 Data Transport Requirements (Mission Phase) (1 of 2)

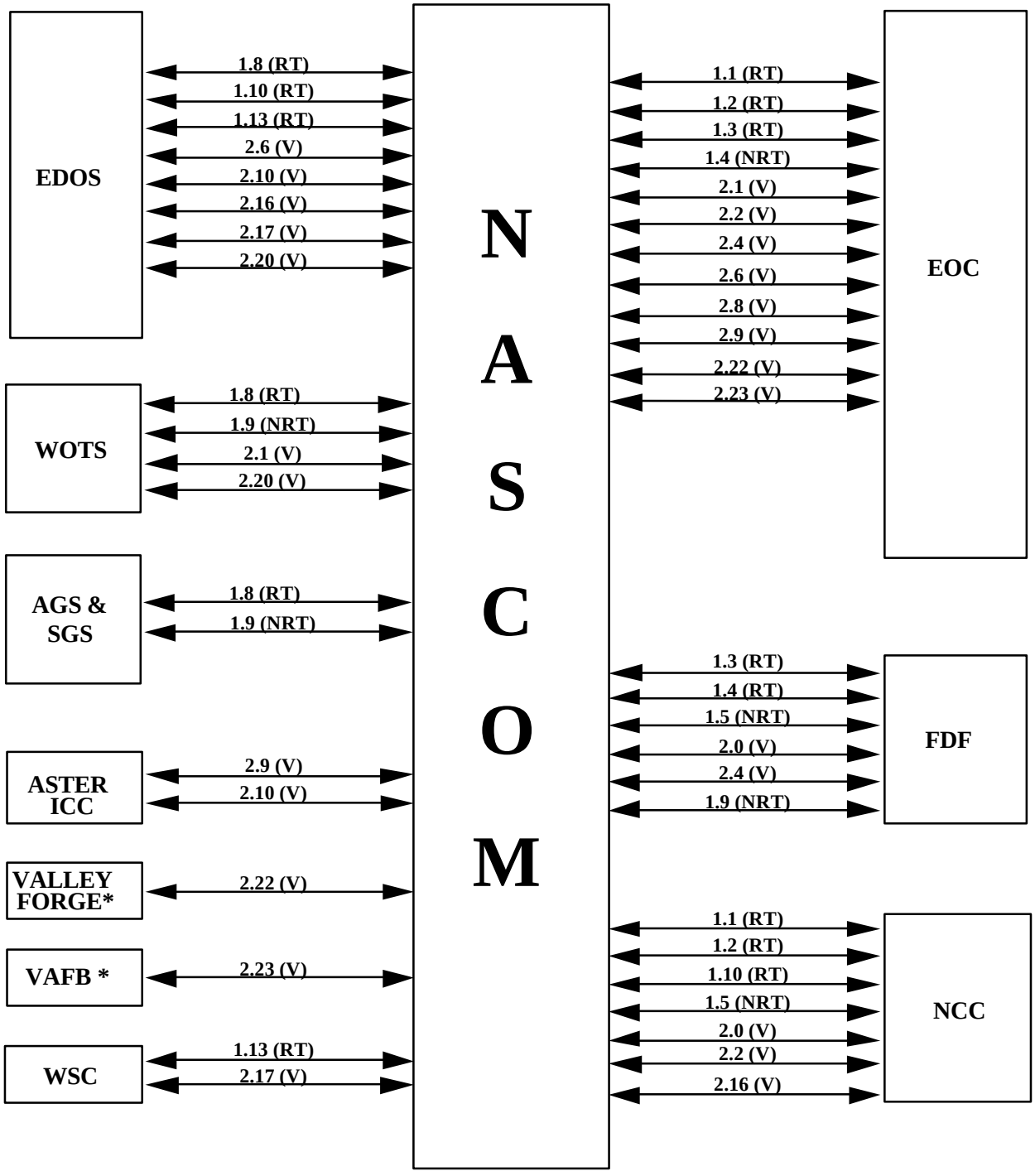
EOS AM-1 5150 — Ground-to-Ground Data Transport Requirements (Mission Phase)

Item No.	Terminals (Comm. Paths Req'd Between) A	B	Type Comm Req'd	Capa-bility 1 Way or 2 Way	Data Data Source	Source Data Rate	Delivery Time	Ref'd Page	Service Date(s) & Duration	Req. Class
2.0	FDD	NCC	Voice	2W		N/A			Launch to EOL	1
2.1	EOC	WOTS	Voice	2W		N/A			Launch to EOL	1
2.2	EOC	NCC	Voice	2W		N/A			Launch to EOL	1
2.3	Deleted									
2.4	EOC	FDD	Voice	2W		N/A			Launch to EOL	1
2.5	Deleted									
2.6	EOC	EDOS	Voice	2W		N/A			Launch to EOL	1
2.7	Deleted									
2.8	EOC	EBnet	Voice	2W		N/A			Launch to EOL	1
2.9	EOC	ASTER ICC	Voice	2W		N/A			Launch to EOL	1
2.10	ASTER ICC	EDOS	Voice	2W		N/A			Launch to EOL	1
2.11	Deleted									
2.12	Deleted									
2.13	Deleted									
2.14	Deleted									
2.15	Deleted									
2.16	EDOS	NCC	Voice	2W		N/A			Launch to EOL	1
2.17	EDOS	WSC	Voice	2W		N/A			Launch to EOL	1
2.18	Deleted									
2.19	Deleted									
2.20	EDOS	WOTS	Voice	2W		N/A			Launch to EOL	1

Figure 5150.1 Data Transport Requirements (Mission Phase) (2 of 2)

Response:Requirements will be met

5155-1



*** Lines are not required for mission phase**

Figure 5155.1 -Communications Diagram

6000-0

The data processing functions are performed by Code Y funded facilities. Code Y data processing is summarized below.

The Code Y data processing facilities are a part of the EOS Data and Information System (EOSDIS). The EOSDIS components addressed are as follows:

- EOS Data and Operations System (EDOS)
- EOS Operations Center (EOC)
- Distributed Active Archive Centers (DAACs)

The data received from the EOS AM-1 spacecraft and instruments, via TDRSS at the White Sands Complex, are delivered to the EDOS. EDOS will provide real-time forward and return link data handling services between the White Sands Complex (WSC) and the EOC to support command and control and health and safety monitoring functions. Real-time housekeeping will be delivered to the ASTER ICC. EDOS also provides a rate buffered service to selected customers, such as the NOAA facility in Maryland. The rate buffered service will make raw data available for delivery within 5 minutes of receipt of the entire data set at the EDOS facility at GSFC for a TDRS contact period.

EDOS will also be responsible for the initial data processing (level 0). Level 0 processing consists of packet time-order sequencing, data transmission artifact removal, data overlap removal and data quality checking. The level zero data are then transferred to a designated DAAC responsible for further processing of a particular instrument. Level 0 ASTER and housekeeping data are delivered to the ASTER GDS via physical media.

EOSDIS levels 1 through 4 science data processing, product generation, distribution, and archival will be performed at geographically distributed centers. These centers, known as DAACs, are facilities with resident expertise in specific Earth science disciplines. EDOS will send different subsets of the EOS data stream, depending on their science discipline specialty, to each DAAC, where they will undergo high level data processing and product generation.

The ASTER Ground DataSystem (GDS) processes the level zero ASTER data and generates level 1 data products, which are then transferred to a DAAC for further processing.

EOS AM-1 7000 —Trajectory and Attitude Support Requirements Summary

7000-1

The Flight Dynamics Division (FDD) shall be responsible for providing orbit, attitude, and mission analysis support to the EOS AM-1 mission. Orbit support shall include generation of predictive orbit ephemeris, generation of onboard navigation system required input parameters, and evaluation of onboard position estimates. The principal navigation system on EOS AM-1 is TDRSS Onboard Navigation System (TONS). Attitude support shall include all ground attitude determination and control, and attitude sensor alignment, calibration, and evaluation. FDD shall also be responsible for providing mission analysis support products. FDD shall provide support during pre-launch and post-launch phases of EOS AM-1.

The post-launch phases to be supported by FDD are:

1. Launch/Acquisition - begins with the transition to internal power before launch. During this phase, the spacecraft will null any attitude rates and perform Earth acquisition. It also includes the delta-V maneuvers required to establish the operational orbit.

2. Checkout - begins after the initial delta-V maneuvers are complete. Includes initialization and checkout activities prior to normal operations.

3. Operational - begins after initialization and checkout activities are complete. Includes operations and maintenance activities to maintain nominal orbit and health and safety.

FDD responsibilities can be summarized as:

- Spacecraft Controls Computer (SCC) Support.
  - Generate EOS AM-1 and TDRS state vectors
  - Generate guide star catalog
  - Perform attitude and orbit validation
  - Provide attitude verification support
  - Provide backup EOS and TDRS orbital elements
- Calibration Support
  - Calibrate alignments of the fine Sun sensor (FSS), Solid State Star Tracker (SSST), and inertial reference units (IRUs)
  - Calibrate the FSS field-of-view (FOV) calibration coefficients
  - Calibrate the IRU scale factors and drift rate biases
  - Calibrate TONS tuning parameters during operational checkout
- General mission and planning support
  - Determine coarse real-time EOS AM-1 attitude
  - Provide mission planning aids
  - Provide attitude sensor hardware performance monitoring
  - Determine predictive EOS AM-1 orbit ephemeris and perform maneuver prediction and planning
  - Estimate spacecraft oscillator frequency bias
  - Provide near-real-time maneuver monitoring
  - Provide acquisition data

EOS AM-1 7100 — Attitude Determination and Control Requirements

7100-0

The following sections provide the FDD requirements for support of EOS AM-1 attitude determination and control. The requirements detailed are for attitude determination and validation, sensor calibration and alignment, and SCC support. Previously numbered requirements 7100-1 through 7100-11 are now described in detail in sections 7110 through 7150.

EOS AM-1 7110—Attitude Determination Support

7110-1

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall derive the EOS coarse attitudes in real-time.	EOS real-time attitude	Pre-Launch (simulation) Launch/ Acquisition Checkout Operational	Parameters: Roll, Pitch, Yaw Euler angles Accuracy: ±1° 3-sigma each axis after calibration. ±7° 3-sigma each axis before calibration. Derived from all available attitude sensors when valid Response: The displayed solutions shall be electronically delivered to the EOC within 8 seconds of receipt of telemetry data. Frequency: All real-time passes during launch/acquisition and checkout, during scheduled simulations, maneuvers, anomalies, and upon request of the EOC Reference: Units shall be in degrees. See discussion for coordinate system definition

Response: Requirement will be met

7110-2

FDD shall use the Master Reference Cube (MRC) to define the zero attitude reference of the spacecraft. Zero attitude error shall exist when the line normal to the pitch-roll surface of the MRC is parallel to the radius vector from the spacecraft center of mass to the center of the earth (i.e., parallel to the Z-axis), and the roll-yaw surface of the MRC is parallel to the plane of the orbit.

Response: Requirement will be met

7110-2.1

The pitch axis (Y) shall be oriented normal to the orbit plane, with positive sense opposite to that of the orbit's angular momentum vector.

Response: Requirement will be met

7110-2.2

The yaw axis (Z) shall be positively oriented earthward, parallel to the satellite radius vector from the spacecraft center of mass to the center of Earth.

Response: Requirement will be met

7110-2.3

The roll axis (X) shall be positively oriented in the direction of orbital flight, completing an orthogonal triad with the Y-axis and Z-axis.

Response: Requirement will be met

7110-3

FDD shall express the attitude as a 3-1-2 Euler rotation.

Response: Requirement will be met

EOS AM-1 7120—Attitude Sensor Evaluation and Alignment Support

7120-1

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall trend the SSST for stability of alignment, sensitivity of star magnitude measurements.	Trend Report Alarm Notification	Checkout Operational	Parameters: N/A Accuracy: N/A Response: Delivery to EOC shall be as defined in the ECS FDD ICD Frequency: Monthly and as needed Reference: N/A

Response: Requirement will be met.

7120-2

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall trend the IRUs for drift stability.	Trend Report Alarm Notification	Checkout Operational	Parameters: N/A Accuracy: N/A Response: Delivery to EOC shall be as defined in the ECS FDD ICD Frequency: Monthly and as needed Reference: N/A

Response: Requirement will be met.

7120-3

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC the SSST alignment matrix.	SSST alignment matrix	Checkout Operational	Parameters: SSST 1&2Euler Parameter Accuracy: N/A Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: Once during Checkout. As needed during Operational phase Reference: As specified by FOT

Response: Requirement will be met.

7120-4

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC the SSST star scale factors.	SSST scale factor coefficients	Checkout Operational	Parameters: SSST 1&2 starmagnitude, angle, and coordinate scale factors Accuracy: N/A Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: Once during Checkout. As needed during Operational phase Reference: N/A

Response: Requirement will be met.

7120-5

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC the IRU alignment matrix.	IRU alignment matrix	Checkout Operational	Parameters: IRU alignment matrix Accuracy: N/A Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: Once during Checkout. As needed during Operational phase Reference: As specified by FOT

Response: Requirement will be met

7120-6

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC the IRU scale factors.	IRU scale factors	Checkout Operational	Parameters: IRU1 and IRU2 scale factors Accuracy: N/A Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: Once during Checkout. As needed during Operational phase Reference: N/A

Response: Requirement will be met

7120-7

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC FSS field-of-view calibration parameters.	FSS field-of-view parameters	Checkout Operational	Parameters: FSS field-of-view parameters Accuracy: N/A Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: Once during Checkout. As needed during Operational phase Reference: N/A

Response: Requirement will be met

7120-8

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC the FSS alignment matrix .	FSS alignment matrix	Checkout Operational	Parameters: Euler Parameters Accuracy: N/A Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: Once during Checkout. As needed during Operational phase Reference: As specified by FOT

Response: Requirement will be met

7120-9

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall trend FSS calibration stability.	Trend Report Alarm Notification	Checkout Operational	Parameters: N/A Accuracy: N/A Response: Delivery to EOC shall be as defined in the ECS FDD ICD Frequency: Monthly and as needed Reference: N/A

Response: Requirement will be met.

EOS AM-1 7130—Attitude Maneuver and Control Support

7130-1

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall define spacecraft maneuvers required to perform alignment calibration of attitude sensors. FDD shall work with the Flight Ops Team to plan the necessary maneuvers.	Maneuver profiles	Checkout Operational	Parameters: Table of single-axis rotations Accuracy: N/A Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: Once during Operational Initialization phase As needed during Operational phase Reference: MRC

Response: Requirement will be met

7130-2

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC predicted spacecraft attitude angles and rates for FOT scheduled attitude maneuvers.	Attitude predictions	Launch/Acquisition Checkout Operational	Parameters: Table of attitude predictions versus time Accuracy: Best effort Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: As needed Reference: MRC

Response: Requirement will be met.

EOS AM-1 7140—Onboard Computer Support Processing and Verification

7140-1

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall validate SCC attitude determination.	Alarm notification	Launch/Acquisition Checkout Operational	Time Span: N/A Accuracy: SCC attitude determination shall be accurate to 41 arcsec in roll, 44 arcsec in pitch, and 36 arcsec in yaw (3-sigma) Response: Delivery to EOC shall be as defined in the ECS FDD ICD Frequency: As needed Reference: N/A

Response: Requirement will be met

7140-2

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOS Mission Star Catalog to the EOC and spacecraft contractor. FDD shall provide additions or deletions to the EOC when the Catalog is changed.	EOS MISSION STAR CATALOG	Prelaunch and as needed.	Parameters: Skymap Epoch date, Skymap ID number, star scientific name, star position unit vector, star instrument magnitude, star spectral class Accuracy: 0.6 arcsec Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: Once prior to launch, as needed after launch Reference: mean of J2000

Response: Requirement will be met

7140-3 Deleted

7140-4

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide to EOC the SSST star density profile	Star density profile	Launch/Acquisition Checkout Operational	Parameters: For each SSST: Star ID minimum, maximum, and average orbit angle separation between stars Accuracy: N/A Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: 3-week predictions once a week Reference: N/A

Response: Requirement will be met

7140-5

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide to the EOC the star interference times.	Star interference table	Launch/Acquisition Checkout Operational	Parameters: Star ID SSST ID FOV entrance and exit times Interference start and stop times Interference type Accuracy: 0.1 seconds Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: 72-hour predict once a day Reference: N/A

Note: SSST interference is based on angle between sun/moon/planet and SSST boresight.
Response: Requirement will be met

7140-6 Deleted

7140-7

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide to EOC a table of sun and moon interference times of the ESA	ESA interference table	Launch/Acquisition Checkout Operational	Parameters: ESA number, start and stop interference times, interfering object Accuracy: 60 sec absolute at end of 3 week prediction Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: 3 week product: Once a week Reference: UTC

Response: Requirement will be met.

7140-8

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide to EOC a table of FSS sun visibility times and alpha and beta angles for nominal attitude.	FSS visibility table.	Launch/Acquisition Checkout Operational	Parameters: FSS visibility times Accuracy: 60 sec absolute at end of 3 week prediction Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: 3 week product: Once a week Reference: UTC

Response: Requirement will be met

7200-0

The following sections provide the FDD requirements for onboard orbit determination evaluation and calibration, predictive orbit information, orbit maneuver planning, and TDRSS and WOTS/AGS/SGS ground station contact predictions..

EOS AM-1 7210—Trajectory Determination and Error Analysis

7210-1

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall perform quality assurance of the onboard navigation system performance.	Report	All	Time Span: Mission life Accuracy: Onboard navigation system shall be maintained to 150 meters/axis and velocity to 0.160 meters/seconds 3-sigma Response: Delivery to EOC shall be as defined in the ECS FDD ICD. Frequency: TONS initialization to +2 days: once per orbit, +2 days to +7 days: once per day, +7 days to TONS deactivation: once per week, and after all maneuvers Reference: Mean of J2000

Response: Requirement will be met

7210-2

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall have the capability to emulate the onboard navigation system flight software.	onboard navigation system emulator	All	Time Span: Mission life Accuracy: Refer to 7210-1 Response: N/A Frequency: N/A Reference: N/A

Response: Requirement will be met

7210-3

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide statistical analysis of measurement residuals and state residuals.	Report	All	Time Span: Mission life Accuracy: Refer to 7210-1 Response: Delivery to EOC shall be as defined in the ECS FDD ICD Frequency: N/A Reference: N/A

Response: Requirement will be met

7210-4

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall use the onboard navigation system emulator to perform diagnostics and test proposed algorithms and data base parameter modifications.	Report	All	Time Span: Mission life Accuracy: Refer to 7210-1 Response: Delivery shall be as defined in the ECS FDD ICD Frequency: N/A Reference: N/A

Response: Requirement will be met

7210-5

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide to the EOC an initial EOS state vector and time tag.	EOS AM-1 state vector (see discussion)	Launch/Acquisition Checkout Operational	Time Span: N/A Accuracy: Position shall be ±300 meters (3-sigma), Velocity shall be ± 0.33 meters/second (3-sigma) Response: Delivery to the EOC shall be as defined in the ECS FDD ICD The time tag of state vector shall be +10/+100 min. ahead of the planned uplink time Frequency: As needed to initialize onboard navigation system Reference: See discussion

Note: The EOS state vectorshall consist of: time tag in UTC, spacecraft X, Y, Z position and X, Y, Z velocity in meters and meters/sec in the mean of J2000 frame, Drag Scale Factor, master oscillator frequency bias, and TDRS measurement bias.

Response: Requirement will be met

7210-6

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC an initial EOS TONS state error covariance matrix.	Error covariance matrix	Launch/Acquisition Checkout Operational	Time Span: N/A Accuracy: N/A Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: As needed to initialize onboard navigation system Reference: Mean of J2000

Response: Requirement will be met

7210-7

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide TDRSS state vectors for all operational TDRSS spacecraft.	TDRS State Vectors	Prelaunch (Simulations) Launch/Acquisition Checkout Operational	Time Span: N/A Accuracy: Onboard propagation shall maintain 75 m position and 0.0055 m/sec velocity 3-sigma after one day Response: Delivery to the EOC shall be as defined in the ECS FDD ICD State vector time tag shall be +10 to +100 min. ahead of uplink time Frequency: Once per day. Delivery shall also be made after each TDRS maneuver and as needed prelaunch for simulations Reference: Mean of J2000

Note: The TDRS state vectorshall consist of a time tag in UTC, X, Y, Z position, X, Y, Z velocity, and valid time limit in UTC. The valid time limit shall be a fixed delta from the state vector epoch unless a TDRS maneuver is planned during the valid time. Otherwise if a TDRS maneuver is planned, the time limit shall be the start time of when the TDRS is no longer usable for navigation.

Response: Requirement will be met

7210-8

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide to the EOC the TDRS mass and solar pressure coefficient for each TDRS.	TDRS mass and solar pressure coefficient	Launch/Acquisition Checkout Operational	Time Span: N/A Accuracy: Best available Response: Delivery to EOC shall be as defined in the ECS FDD ICD Frequency: Daily and after each TDRS maneuver Reference: Kg

Response: Requirement will be met

7210-9

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide to the EOC the EOS AM-1 Brouwer-Lyddane mean orbit elements.	EOS AM-1 Brouwer-Lyddane mean orbit elements	Launch/Acquisition Checkout Operational	Time Span: N/A Accuracy: Onboard propagation shall maintain 50 Km position over 2 days Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: Once per day. Delivery shall also be made after ELV separation and after each orbit adjust maneuver Reference: Mean of J2000

Note: EOS AM-1 Brouwer-Lyddane mean orbit elements shall include epoch time, semimajor axis, eccentricity, inclination, right ascension of ascending node, argument of perigee, mean anomaly, semimajor axis rate, right ascension rate, argument of perigee rate, and mean anomaly rate. FDD shall provide the capability of setting selected rate terms to zero.

Response: Requirement will be met

7210-10

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide to the EOC the TDRSS Brouwer-Lyddane mean orbit elements for all operational TDRSS spacecraft.	TDRS Brouwer-Lyddane mean orbit elements	Launch/Acquisition Checkout Operational	Time Span: N/A Accuracy: Onboard propagation shall maintain 120 Km positionover 2 days Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: Once per day. Delivery shall also be made after each TDRS maneuver Reference: Mean of J2000

Note: TDRS Brouwer-Lyddane mean orbit elements shall include epoch time, semimajor axis, eccentricity, inclination, right ascension of ascending node, argument of perigee, mean anomaly, semimajor axis rate, right ascension rate, argument of perigee rate, and mean anomaly rate. FDD shall provide the capability of setting selected rate terms to zero.

Response: Requirement will be met

7210-11

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC the UTC to UT1 timing difference.	UTC to UT1 timing difference	Launch/Acquisition Checkout Operational	Time Span: 1 day Accuracy: ± 0.001 sec Response: Delivery to the EOC shall be as defined in the ECS FDD ICD. Frequency: Daily Reference: UTC

Note: FDD acquires the UTC to UT1 timing difference value from the Naval Observatory via the Internet.

Response: Requirement will be met

7210-12

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide to the EOC an independent estimate of the Spacecraft oscillator frequency bias.	Oscillator frequency bias	Launch/Acquisition Checkout Operational	Time Span: N/A Accuracy: +/- 1 Hz Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: Once per day (Checkout Phase). Once per week, and as needed after Master Oscillator adjustments (Operational Phase) Reference: N/A

Response: Requirement will be met

7210-13

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the ECS SDPS repaired ephemeris data as needed.	Definitive ephemeris	Operational	Time Span: As needed Accuracy: 150 m/axis 3-sigma Response: Delivery to SDPS shall be as defined in the ECS FDD ICD Frequency: Delivery to SDPS shall be as defined in the ECS FDD ICD Reference: Mean of J2000

Response: Requirement will be met

7210-14

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC predicted EOS ephemeris.	Predictive ephemeris	Launch/Acquisition Checkout Operational	Time Span: 7 week 7 day Accuracy: End of 40 hrs: 330 m along-track 50 m cross-track 30 m radial 2 m/s Velocity 3-sigma Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: Mean of J2000

Response: Requirement will be met

7210-15

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide to the EOC predicted solar, lunar, and planetary ephemeris.	SLP ephemeris	All	Time Span: N/A Accuracy: N/A Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: As needed Reference: Mean of J2000

Response: Requirement will be met

7210-16

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC and spacecraft contractor: - simulated Doppler data - simulated EOS AM-1 ephemeris data, state vectors, and Brouwer-Lyddane orbital elements - simulated TDRS ephemeris data, state vectors, and Brouwer-Lyddane orbital elements - simulated value of UT1-UTC	Simulated ephemeris and state vectors	All	Time Span: As needed Accuracy: N/A Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: As needed Reference: Mean of J2000

Response: Requirement will be met

7210-17

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC TONS initialization data, filter model and tuning parameters, and FDIR parameters.	Onboard navigation system filter tuning parameters	Launch/Acquisition Checkout Operational	Time Span:N/A Accuracy:N/A Response: Delivery to the EOC shall be as defined in the ECS FDD ICD. Frequency: As needed Reference: parameter dependent

Response: Requirement will be met

7210-18 Deleted
7210-19 Deleted
7210-20 Deleted

7210-21

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC predicted TDRS ephemeris (for all operational TDRSs)	Predicted TDRS ephemeris	All	Time Span: 7 weeks, 7 days Accuracy: Best effort Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: Mean of J2000

Response: Requirement will be met.

7210-22

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC post maneuver report	Post maneuver report	Launch/Acquisition Checkout Operational	Time Span: N/A Accuracy: Best effort Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: After each EOS AM-1 delta-V maneuver Reference: N/A

Response: Requirement will be met.

7210-23

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC an estimate of the Ku-band oscillator frequency.	Ku-band oscillator frequency report	Checkout Operational	Time Span: N/A Accuracy: 5 Hz Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: Once per week Reference: N/A

Response: Requirementwill be met

7220-1

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall monitor the EOS AM-1 orbital elements for frozen orbit conditions, ground track limits, and Sun-synchronous orbit conditions and notify the FOT of needed orbit adjust.	Orbit adjust maneuver request	All	Accuracy: Ground track repeat shall be maintained to within ± 20 Km, the descending node mean time shall be maintained at 10:30 AM ± 15 min, and radial orbit position repeatability for a given latitude shall be +10/-5 Km Response: 5 weeks prior to maneuver Frequency: As needed Reference: UTC

Note: The 5 week notification will be used to schedule TDRSS support during the maneuver.

Response: Requirement will be met

7220-2

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC the "required delta-V maneuver parameters and maneuver attitude to maintain frozen orbit conditions, ground track repeat limits, and Sun-synchronous orbit conditions.	Orbit adjust maneuver parameters	Launch/Acquisition Checkout Operational	Accuracy: Ground track repeat shall be maintained to within ± 20 Km, the descending node mean time shall be maintained at 10:30 AM ± 15 min, and radial orbit position repeatability for a given latitude shall be maintained to +10/-5 Km Response: Preliminary parameters 24 hours prior to maneuver and final updates no less than 4 hours prior to maneuver. During contingency operations, delivery of parameters is required at least 1 hour prior to the maneuver. Delivery to the EOC shall be as defined in the ECS FDD ICD. Frequency: As needed Reference: UTC

Response: Requirement will be met

7220-3

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC an estimate of the Spacecraft mass and center of mass location.	Mass and Center of mass location	Launch/Acquisition Checkout Operational	Accuracy: Best available Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: After each spacecraft orbit adjust Reference: meters in Spacecraft body coordinates and kg

Response: Requirement will be met.

EOS AM-1 7230—Acquisition Data (Network Support)

7230-1

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide EOC and NCC a table of EOS AM-1 Omni antenna to all operational TDRSs viewing entrance and exit times.	Table of all operational TDRSs contact times via Omni antenna	All	Time span: 7 weeks 7 days Accuracy: 60 sec absolute UTC at end of 3 week prediction Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met

7230-2

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide EOC and NCC a table of EOS AM-1 HGA to all operational TDRSs viewing entrance and exit times (attitude dependent). FDD shall account for viewing constraints to include: antenna constraints, Sun angle constraint, and atmospheric height.	Table of all operational TDRSs contact times via HGA	All	Time span: 7 weeks 7 days Accuracy: 60 sec absolute UTC at end of 3 week prediction Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met

7230-3

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide EOC and NCC a table of EOS AM-1 Omni antenna to Project-specified ground stations and WOTS/AGS/SGS viewing entrance and exit times and maximum elevation angle during contact.	Table of ground station contact times via Omni antenna	All	Time span: 7 weeks 7 days Accuracy: 60 sec absolute UTC at end of 3-week prediction Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met

7230-4

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide WOTS/AGS/SGS nominal and 3-sigma launch injection parameters.	Injection Parameter Report	Pre Launch	Accuracy: Best effort based on launch vehicle contractor data Response: As defined in ICD Frequency: N/A Reference: As defined in ICD

Response: Requirement will be met

7230-5 Deleted
7230-6 Deleted
7230-7 Deleted

7230-8

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide to the EOC a table of HGA to all operational TDRSs gimbal angles as a function of time (attitude dependent).	Table of all operational TDRSs Alpha and Beta angles	All	Time span: 7 weeks 7 days Accuracy: 0.5 deg. at end of 3 day prediction Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: HGA

Response: Requirement will be met

7230-9

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide to the EOC predicted EOS AM-1 range data for use in RDD time correlation.	Range Predicts	Launch/Acquisition Checkout Operational	Time Span: 1 day Accuracy: Best effort Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: Daily

Response: Requirement will be met.

7230-10

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide state vectors to WOTS/AGS/SGS, and direct playback sites.	Spacecraft state vectors	Launch/Acquisition Checkout Operational	Time Span: N/A Accuracy: Best available Response: Delivery shall be as defined in ICDs Frequency: As defined in ICDs

Response: Requirement will be met.

EOS AM-1 7230—Acquisition Data (Network Support)

7230-11

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC a table of X-band broadcast interference times for EOS AM-1 with all DSN sites.	Table of interference times	All	Time Span: 7 weeks 7 days Accuracy: 1 sec at 9 days Response: Delivery shall be as defined in the ECS FDD ICD. Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met.

7230-12

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC a table of EOS AM-1 Direct Access System antenna to Project-specified ground stations viewing entrance and exit times and maximum elevation angle during contact (attitude dependent). FDD shall account for spacecraft antenna viewing constraints.	Table of ground station contact times via Direct Access System antenna	All	Time span: 7 weeks 7 days Accuracy: 60 sec absolute UTC at end of 3-week prediction Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met

7230-13

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall deliver to the EOC a table of EOS AM-1 to project-specified instrument field campaign target sites viewing entrance and exit times and maximum elevation angle during view period	Table of ground site visibility times in instrument field-of-view	All	Time span: Up to 7 weeks (negotiable for time spans exceeding 7 weeks) Accuracy: 60 sec absolute UTC at end of 3-week prediction Response: Delivery to the EOC shall be as defined in the ECS FDD ICD Frequency: As requested Reference: UTC

Response: Requirement will be met

EOS AM-1 7300—Mission Scheduling and Operational Planning Aid Support Requirements

7300-1

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted times of planned spacecraft maneuvers.	Predicted times of maneuvers	All	Time Span: 7 weeks 18 months Accuracy: ±1 Orbit at 7 weeks ±1 day at 6 mos Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 18 months: Monthly Reference: UTC

Note: The planned maneuver times are for science team notification.

Response: Requirement will be met.

7300-2

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted Solar azimuth and elevation angles in instrument defined frame based on instrumenter-supplied instrument frame of reference. (MODIS, MISR, MOPITT, CERES)	Solar azimuth and elevation angles vs. time	Checkout Operational	Time Span: 7 weeks 7 days Accuracy: 0.07 deg at 9 days 30 sec resolution Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: Instrument defined frame, UTC

Response: Requirement will be met.

7300-3

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted Lunar azimuth and elevation angles in instrument defined frame. (MODIS, MISR)	Lunar azimuth and elevation angles vs. time	Checkout Operational	Time Span: 7 weeks 7 days Accuracy: 0.07 deg at 9 days Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: Instrument defined frame, UTC

Response: Requirement will be met.

EOS AM-1 7300—Mission Scheduling and Operational Planning Aid Support Requirements

7300-4

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted solar eclipse entrance/exit times of subsatellite point.	Solar eclipse entrance/exit times	Checkout Operational	Time Span: 7 weeks, 7 days Accuracy: Best available Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly (as needed) 7 days: Daily (as needed) Reference: UTC

Response: Requirement will be met.

7300-5

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted entrance and exit times of the South Atlantic Anomaly and Van Allen Belt.	Entrance and Exit Times to the SAA and Van Allen Belt	Checkout Operational	Time Span: 7 weeks 7 days Accuracy: 1 sec at 9 days Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met.

7300-6

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted Solar beta angles.	Solar beta angles vs. time	Checkout Operational	Time Span: 7 weeks 7 days Accuracy: 0.07 deg at 9 days 1 orbit resolution Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met.

7300-7

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted local Sun time at the ascending and descending node.	Local Sun time vs. time	Checkout Operational	Time Span: 7 weeks 7 days Accuracy: 1 sec at 9 days Response: Delivery shall be as defined in the ECS FDD ICD. Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met.

7300-8

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted spacecraft day/night transition times.	Spacecraft Day/Night transition times	All	Time Span: 7 weeks 7 days Accuracy: 1 sec at 9 days Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met.

7300-9

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted Lunar beta angles	Lunar beta angles vs. time	Checkout Operational	Time Span: 7 weeks Accuracy: 0.07 degrees at 9 days Response: Delivery shall be as defined in the ECS FDD ICD Frequency: Weekly Reference: UTC

Response: Requirement will be met.

7300-10

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted Sun and/or Moon entrance and exit times into instrument defined field of views based on instrumenter-supplied field of view (MODIS, MISR).	Sun/Moon visibility times	Checkout Operational	Time Span: 7 weeks 7 days Accuracy: 1 sec at 9 days Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met.

EOS AM-1 7300—Mission Scheduling and Operational Planning Aid Support Requirements

7300-11

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted times when Planets and MODIS-specified stars are within 10 degrees of the Moon while the Moon is in specified instrument FOV (MODIS, MISR).	Moon/ Planet/Star visibility times	Checkout Operational	Time Span: 7 weeks 7 days Accuracy: 1 sec at 9 days Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met.

7300-12

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted sub-satellite point longitude and latitude vs. time and orbit number.	Sub-satellite point latitude and longitude vs. time and orbit number	All	Time Span: 7 weeks 7 days Accuracy: Latitude: 0.005 deg at 40 hrs at equator Longitude: 0.0009 deg at 40 hrs at equator Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met.

7300-13

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted spacecraft altitude.	Spacecraft altitude vs. time	All	Time Span: 7 weeks 7 days Accuracy: 30 meters at 40 hrs Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met.

EOS AM-1 7300—Mission Scheduling and Operational Planning Aid Support Requirements

7300-14

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted ascending and descending node crossing times and longitude at node crossing.	Node crossing times and location	All	Time Span: 7 weeks 7 days Accuracy: 1 sec time, 0.01 deg longitude at 9 days; 0.04 sec at 40 hrs, 0.0009 deg longitude at 40 hrs Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met.

7300-15

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted user line of sight terminator crossing times. (MODIS, MISR)	User line of sight terminator crossing times	Checkout Operational	Time Span: 7 weeks 7 days Accuracy: 1 sec at 9 days Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met.

7300-16

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted length of spacecraft day and night	Spacecraft day and night duration	All	Time Span: 7 weeks, 7 days Accuracy: 1 sec at 21 days Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met.

7300-17

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted time of spacecraft noon.	Time of Spacecraft noon	All	Time Span: 7 weeks Accuracy: 1 sec at 9 days Response: Delivery shall be as defined in the ECS FDD ICD Frequency: Weekly Reference: UTC

Response: Requirement will be met.

EOS AM-1 7300—Mission Scheduling and Operational Planning Aid Support Requirements

7300-18 Deleted

7300-19

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted crossing times of maximum and minimum latitudes (i.e., orbit north and south).	Max and Min latitude times	Checkout Operational	Time Span: 7 weeks 7 days Accuracy: 1 sec at 9 days; 0.04 sec at 40 hrs Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met.

7300-20

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted nadir terminator crossing times.	Nadir terminator crossing times	Checkout Operational	Time Span: 7 weeks 7 days Accuracy: 1 sec at 9 days; 0.04 sec at 40 hrs Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily Reference: UTC

Response: Requirement will be met.

7300-21

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted orbit start (ascending node crossing) times with associated orbit numbers.	Predicted orbit start times	Launch/Acquisition Checkout Operational	Time Span: 7 weeks 7 days Accuracy: Best available Response: Delivery shall be as defined in the ECS FDD ICD Frequency: 7 weeks: Weekly 7 days: Daily

Response: Requirement will be met.

7300-22

Detailed Requirement	Product	Mission Phase	Performance Requirement
FDD shall provide the EOC predicted apogee and perigee altitudes with associated times of occurrence.	Apogee and Perigee altitudes and time of occurrence	Launch/Acquisition Checkout Operational	Time Span: 7 days Accuracy: Best effort Response: Delivery to EOC shall be as defined in the ECS FDD ICD Frequency: Daily Reference: UTC

Response: Requirement will be met.

Appendix A. Mission Requirements Request (MRR)

Appendix A. Mission Requirements Request (MRR)

AM-1 MRR
November 30, 1992

Appendix D. Issues To Be Solved (as of 11/13/96)

Appendix D. Issues To Be Solved (as of 11/13/96)

Text Description	Ref Page Title No.	TBD, TBR, TBS	Critical Path Date